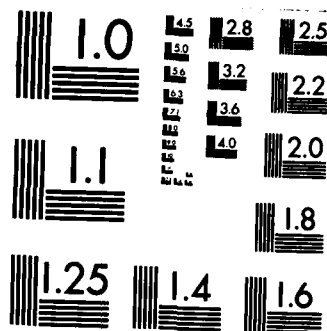END

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TRAINING TECHNOLOGY HANDBOOK DEVELOPMENT:
PHASE I. ANNOTATED LITERATURE REVIEW

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**NAVY PERSONNEL RESEARCH
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TRAINING TECHNOLOGY HANDBOOK DEVELOPMENT:
PHASE I. ANNOTATED LITERATURE REVIEW

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FOREWORD

This literatuare review has been performed in support of Navy Decision Coordinating Paper, NDCP-Z0109-PN, under subproject Z0109-PN.03 (Manpower Cost in System Design) and was sponsored by the Deputy Chief of Naval Operations (Manpower, Personnel, and Training, OP-01). The subproject is directed to the reduction of manpower requirements and associated life cycle costs of new hardware systems. Information and techniques are being developed for use in assisting hardware developers in assessing the people-related implications of their designs and for use in conducting cost-effectiveness trade studies during the design process.

This report provides an annotated bibliography of technical literature relevant to identification of major training, personnel, and cost variables to be considered in projecting future training system requirements. The literature review was completed late in 1978. Results are being used to develop a training technology handbook that will assist systems acquisition and training managers in forecasting training system course requirements.

The contracting officer's technical representative was Mr. John F. Brock.

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CONTENTS

INTRODUCTION

Problem

The Navy is presently faced with unprecedented personnel and training requirements. While personnel resources continue to dwindle in number and quality, rapid increases in the sophistication of modern weapon systems have created an increasing demand for highly trained personnel. Improved methods for projecting training costs are needed if the Navy is to implement and support essential training programs within the constraints of austere training budgets.

To achieve this goal, the Navy needs better cost and training effectiveness methodologies to provide both weapons and training system managers with a more factual basis for justifying proposed training programs. Such techniques are also needed for facilitating development of training programs, estimating the relative advantages of alternative training methods and associated training devices, and providing feedback to the development/design process for emerging and future weapon systems. Valid and dependable analyses of cost and training effectiveness are also needed to identify basic and applied research requirements in the areas of training technology, personnel requirements, and hardware design.

A major problem in weapon system development has been the tendency to overemphasize the performance and cost of the hardware subsystem, while underestimating the importance of other subsystems such as personnel, training, and logistics. If the systems concept is to drive the acquisition process, then the criterion of system effectiveness should be used to measure each subsystem's contribution to the overall system performance. Only in this way can correct and timely trade-off analyses be conducted at the proper points in the weapons system acquisition process (WSAP) to ensure maximum system success.

Background

The current difficulty in projecting training costs and requirements can, in part, be attributed to the complexity of the weapons system acquisition process. One measure of this complexity is the number and variety of official Navy and DoD directives pertaining to the process. The 1975 issue of the Department of the Navy RDT&E Management Guide lists more than 200 directives as references. The training system acquisition process is similarly complex.

Until recently, training system requirements were rarely addressed in detail until late in the development of operational systems. System development was viewed as a sequence of events in which the determination of training requirements was a separate and distinct activity. Furthermore, training programs (and training device designs) were typically determined solely on the characteristics of operational systems rather than being driven by training objectives. This disjointed process failed to recognize and realize the mutual benefits inherent in an integrated approach to weapon and training system development.

This situation has received attention in the last few years. In a memorandum for secretaries of the military departments dated 17 August 1978, the Assistant Secretary of Defense called for greater emphasis in early forecasting of manpower needs for new weapon systems. Manpower needs were defined as "personnel assets, spaces, policies, planning, training and utilization (including support policies and equipment, capital/labor trade-offs, technical data, job classifications, and organizations)."

Objective

The overall objective of this effort is to develop a handbook for systems acquisition and training managers that will provide them with the tools to make reasonable estimates of the cost and composition of training required for new hardware systems while in the WASP.

The objective of the effort described herein was to review the state of the art in instructional systems design (ISD), training management systems, and training system cost effeciveness.

APPROACH

Reviews were conducted in:

1. The literature on weapon system and training subsystem development to identify potential sources of difficulty in system planning and development.

2. The literature on training subsystems, with particular attention directed toward current developments in task/skill analysis, media selection methods, instructional delivery systems (including individual differences, adaptive training, and team training), and training program assessment.

3. The literature on training cost estimation.

RESULTS

The annotated literature review produced is provided in Appendix A. Each reference citation is accompanied by a description of the reference contents. References selected for annotation provide a comprehensive sample of the range of current literature. Additonal references, including some older, less critical documents, are provided in Appendix B.

CONCLUSIONS AND RECOMMENDATIONS

The data presented here must be refined and further evaluated to identify relationships and interactions among categories of data (e.g., the relationship between particular instructional strategies and the cost of training programs). Furthermore, the appropriateness of particular instructional strategies should be assessed in relation to such factors as student population characteristics, the frequency and duration of the instruction, requirements for individualized and team training, the location of the instruction (OJT, school, etc.), and the purpose of instruction (initial training, refresher training, transfer of training to new equipment, etc.).

APPENDIX A

ANNOTATED LITERATURE REVIEW

ANNOTATED LITERATURE REVIEW

System Concepts

Air Force Systems Command. Human factors engineering: Personnel subsystem (2nd Ed., AFSC design handbook 1-3). Washington, DC: Andrews Air Force Base, January 1972.

This handbook documents Air Force technical knowledge on the considerations and characteristics of the personnel subsystem that have bearing on the design, operation and maintenance of Air Force equipment and systems. The areas covered include: human engineering, which is the information on the physical capabilities and limitations of men used in the design of systems and equipment to ensure safe, reliable, and efficient personnel performance; the biomedical and physiological criteria used in system design to promote health, safety and physical protection of personnel; the personnel and manning factors that bear on the types and numbers of personnel required for system operation and maintenance; the training and training equipment considerations (not complete); the job performance aids that must support task performance within the context of technician capabilities and equipment characteristics; and the development of measures of performance and proficiency (not complete).

Betaque, N., Kennelly, D., & Nauta, F. Navy manpower planning for new weapon systems (Tech. Rep. WN M1801-1). Washington, DC: Logistics Management Institute, August 1978.

This working note, which describes how the Navy establishes manpower needs for new weapon systems, begins by examining how the Navy creates, funds, and fills billets (manpower authorization). Billets for ships are derived from requirements contained in ship manning documents (SMDs). These documents are drafted late in the acquisition process and finalized a year after deployment of a system. The SMD describes minimal billets to meet required operational capabilities (ROC) based on the mission phase demanding the most manpower. Final billets, however, often are less than this based on the Navy end strength. Deputy Chiefs of Naval Operations (DCNOs) are mission or warfare sponsors that are responsible for programming billets. DCNO (Surface Warfare) has this responsibility for most surface ships. There is no formal process for deriving authorizations from requirements. DCNO (Surface Warfare) provides input to the Navy Program Objective Memorandum (POM) in the form of sponsor program proposals (SPPs) once a year. The SPP for training is prepared by the Chief, Naval Education and Training (CNET) with assistance of a Training Resources Panel (TRP).

Manpower planning as related to the weapon system acquisition process is considered next. Key documents discussed include the operational requirement, development proposal, Navy decision coordinating paper, and the integrated logistical support plan.

Separate sections are devoted to the determination of manpower requirements for surface ships, aircraft, and strategic weapon systems. Whereas most conceptual development of ships is done in-house by the Naval Ship Engineering Center (NAVSEC), development of aircraft is done by private industry. For surface ships, NAVSEC estimates of manpwer requirements are based on the Manpower Determination Model (MDM). For aircraft, manning is estimated by the Naval Aviation Logistics Center (NALC) based on Navy data on similar aircraft, contractors' estimates, test results, and the experienced analyst's judgment. NAVSEC and NALC methods of estimating manpower requirements are described in detail in the appendices.

The relatively large portion of the report devoted to manpower planning for strategic weapon systems reflects the authors' interest in the unique organization of the Strategic

Systems Project Office (SSPO). Emphasis is on training system development, because the training system project manager has authority equal to that of the weapon system (hardware) project manager. This ensures that manpower and training considerations are weighted heavily during all phases of weapon system development.

The authors see two major weaknesses in the Navy acquisition review process. Except for strategic systems, weapon system project managers have not been required to integrate manpower and training considerations into weapon system development. As a result, little attention has been given to these concerns. The second problem in the past is that the DCNO (Manpower) was not involved in the acquisition review process. The DCNO (Logistics) was responsible for manpower considerations, but focused attention on more traditional logistics concerns. Recently, a HARDMAN office was established to evaluate manpower considerations, which should help correct the second problem.

Current methods of predicting manpower needs (e.g., MDM, OPNAV 10P-23) should be refined to encompass needs for each readiness condition, rather than computing average needs. Also, the authors suggest that the guidelines in OPNAV 10P-23 are at times confusing, and some of the measures are insensitive and do not provide for manning of manual backups.

Demaree, R. G., Marks, M. R., Smith, W. L., & Snyder, M. T. Development of qualitative and quantitative personnel requirements information (Tech. Rep. AMRL-TDR-62-4). Wright-Patterson Air Force Base, OH: 6570 Personnel Research Laboratory, Aerospace Medical Division, December 1962.

This report describes the technical aspects of qualitative and quantitative personnel requirements information (QQPRI) development. The relationship of QQPRI development to system development is defined, and general constraints impacting on QQPRI development are identified. However, the major component of the report is a description of the specific analysis occurring during QQPRI development. QQPRI is a formal report required for personnel subsystem development that contains manning estimates, describes duty position, and defines the maintenance and control of the operational equipment. A key role of the QQPRI is to assure compatibility of hardware capabilities and procedures with the characteristics of the personnel assigned to the system. QQPRI reports can also be used to project realistic long range personnel requirements. Early emphasis is based in large part upon the logical progression of time-based mission profiles, function definitions, man-machine allocation of functions, and task performance requirements for operation and maintenance of the weapon systems. Subsequent activities focus on detailed analysis of individual task requirements. It must then be determined whether these job duties fit within an existing job specialty or a new specialty is required.

Department of the Air Force. Instructional System Development (AF Manual 50-2). Washington, DC: July 1975.

This manual presents the concepts and the Air Force policy for instructional systems development (ISD). (Detailed procedures for implementation of ISD concepts are given in AFM 50-58.) ISD is a systematic process that ensures application of instructional technology to cause planning and development. Air Force policy is that ISD will be used for all new instructional systems and, where feasible, for modification of existing ones. A five-step procedure model of ISD is presented: Analyze system requirements, define education/training requirements, develop objectives and tests, plan/develop/validate instruction, conduct and evaluate instruction. These steps are similar, but not identical, to the five steps in the interservice procedures ISD model. Some features particularly the media selection of the Air Force ISD model differ from the interservice procedures. In

the Air Force procedure, a type-of-learning by instructional-media matrix is presented. Appropriateness of media for each type of learning is assessed on three scales: presentation, practice, and feedback. The Interservice procedure assigns appropriateness of media on only a single scale. Whereas the Air Force procedure considers only 6 types of learning, the Interservice procedure considers 11. The Air Force manual contains a separate chapter on the application of ISD to knowledge and attitudes. Also, there is a chapter on Air Force technical training that describes the Air Force personnel classification system.

Department of the Navy. Department of the Navy RDT&E management guide (NAVSO P-2457, Rev. 1-75). Washington, DC: U.S. Government Printing Office, 1975.

This guide was developed to provide both experienced and inexperienced R&D personnel with a comprehensive overview of the RDT&E process, directives, and terminology.

Gerry, R. Learning systems: Requirements and technology. The Second Symposium on Cost Effective Learning Through the Application of Computer Technology, Washington, DC, February 1973, 143-153.

The author cites many inadequacies in the general individualized instructional system model. Specifications of requirements is a major deficiency. The author feels that if efforts are made to attend to this need, more precise counseling between people, learning, and the working world will be made possible with additional benefits in terms of personal motivation, interest, and confidence in work assignment and productivity.

Hanson, V. L., & Purifoy, G. R., Jr. TSM guide to training development and acquisition for major systems (Tech. Rep. 78-A7). Alexandria: U.S. Army Research Institute for the Behavioral and Social Sciences, March 1978.

This guide provides TRADOC System Managers (TSM) with an integrated view of weapon system development. Training subsystem development is highlighted as the major focus to ensure that training considerations occur in a timely manner during development of the weapon system. Training Development and the life cycle system management model (LCSMM) are presented separately, and are followed by a discussion of integrating training subsystem acquisition within the LCSMM. Training related events are detailed for each major phase of weapon system development.

Hirshfeld, S. F., & Kochevar, J. W. Training device requirements documents guide (draft): A procedures handbook for directorate of training developments project officers for devices (DTDPOD). Minneapolis: Honeywell Systems and Research Center, October 1978.

The Training Device Requirements Documents Guide was developed to aid Training and Doctrine Command (TRADOC) school personnel in the development of training devices. The procedures handbook specifies how to (1) define training requirements based on data from front-end analysis and (2) perform media analyses. Both of these activities are required prior to initiating the conceptual development of a training device. The handbook presents procedures and decision rules for determining when a training device is required, and when alternative media are more appropriate. When a training device is required, the procedures handbook specifies how initial training device concepts are formalized, validated, and specified in requirements documents. Detailed examples are included to illustrate each type of analysis and requirements document.

Johnson, S. L., Knight, J. R., & Sugarman, R. C. Simulation technology assessment report (B-1 Technical Memorandum SAT-3). Buffalo, NY: Calspan Corporation, July 1975.

Sugarman, R. C. Defining the system in the systems approach to training. Conference on Issues in Air Traffic Control Simulation, Training, and Technology, Second International Learning Technology Congress and Exposition, February 1978.

Laughery, K. R., & Sugarman, R. C. A systems approach to the design of training devices: A model and its application. Proceedings of the Human Factors Society 22nd Annual Meeting, Detroit, October 1978.

In a report delivered to the Air Force as part of the B-1 instructional system development by Johnson, Knight, and Sugarman (1975) and later amplified by Sugarman (1978), the instructional system design process was conceived as a flow of information. The flow of information necessary to design an efficient training system must highlight numerous interactions among facts, assertions, assumptions, and constraints. Although the proposed model presents a series of chronological steps, it explicitly recognizes the iterative nature of the instructional system design process. The necessity for iteration in this process is due to the large interactions between methods/media specification, instructional block and course allocation, and system requirements and constraints. Rather than an algorithm for the design of training systems, this report identifies framework concepts to be used during the design of training systems. This model clearly recognized the strong interdependencies that exist between course design (e.g., syllabus) and resource requirements and constraints (e.g., training aids, dollar limitations).

Later, this systematic approach to training system design was focused to deal specifically with the design of training devices by Laughery and Sugarman (1978). The model presented in this article recognizes that several types of data generated during the instructional system development process, yield valuable information about training device requirements. First, a task analysis is normally conducted that permits the training analyst to examine relatively small units of the human's responsibilities in overall system operations. This enables the training analyst to avoid unnecessary training while still ensuring that all essential tasks are properly trained. On the basis of the task analysis coupled with an analysis of the expected incoming skills and knowledges of students, a set of training objectives is generated. The methodology for designing a set of training devices employs this training objective data base for subsequent analyses. Each training objective is placed into one of five categories indicating the basic type of environment ᵈ for the objective to be properly taught; (1) cognitive (e.g., classroom), (2) ᵃrization (to permit spatial relationships to be determined), (3) procedural (to pern. npsychomotor procedures using controls and displays to be taught and practiced), (4) fully interactive (to permit psychomotor, as well as procedural components of the task to be practiced), and (5) the operational environment itself (where the state of simulation technology cannot provide the appropriate environment artificially). Familiarization, procedural, and fully interactive training objectives may lend themselves to training in a training device while cognitive objectives require no devices and operational equipment requires no specification based on training requirements.

For each of the familiarization, procedural, and fully interactive training objectives an analysis is made to determine the specific environmental characteristics necessary to train that objective. This is done by using judgments regarding the controls and displays involved, the extent to which they must be operable, and what other identifiable environmental cues are relevant to facilitate learning of that objective (e.g., visual, auditory, vestibular).

paper concludes that educators should spend more time developing individual memory and problem-solving skills.

Kurke, M. I. Operational sequence diagrams in system design. Human Factors, 1961, 3, 66-73.

The operational sequence diagram approach presents information/decision/action sequences required of a system, or its constituent component systems, to accomplish prescribed mission objectives. It has been used to establish sequence of operations requirements between subsystem interfaces at various levels of system analysis, to identify problem situations traceable to inadequate hardware, to establish requirements for training programs and associated devices, and to provide information relevant to human factors considerations of workspace layout and control and display design. It has been applied to programs dealing with instrumentation radar, fire control systems, and other types of weapon systems.

Lumsdaine, A. A. Design of training aids and devices. In J. D. Folley, Jr. (Ed.), Human factors methods for system design (Tech. Rep. C90-60-FR-225). Pittsburgh: The American Institute of Research for Office of Naval Research, 1960, 217-290.

The steps to be followed in conducting analyses for training devices are (1) determine the human performance requirements for a job; (2) derive training requirements in terms of skills and knowledge to be acquired; (3) consider logisitic requirements and total training plans; and (4) use a mockup of a device to obtain an informal evaluation of the procedures developed. The procedures are revised based on the tryout results.

Marquardt, L. D., & McCormick, E. J. Attribute ratings and profiles of the job elements of the Position Analysis Questionnaire (PAQ) (Tech. Rep. 1). Lafayette, IN: Purdue University, Occupational Research Center, June 1972.

The purpose of this study was to obtain estimates of reliability of the human attribute requirements of form B of the PAQ. Eighty raters rated the PAQ job elements using a new list of 76 attributes. There is evidence that situational attributes have a lower reliability than aptitude attributes.

Marquardt, L. D., & McCormick, E. J. Component analysis of the attribute data based on the Position Analysis Questionaire (PAQ) (Tech. Rep. 2). Lafayette, IN: Purdue University, Occupational Research Center, 1973.

This paper extends the work on the attribute profiles. Sixty-seven human attributes judged as relevant to work behavior were judged in terms of their relevance to the elements of the PAQ. The underlying structure of human attributes (abilities and situational requirements) is analyzed in terms of co-existence on the job, while, the underlying structure of job elements is analyzed in terms of relevance to human attributes. There seems to be no problem in using this approach.

Marquardt, L. D., & McCormick, E. J. The job dimensions underlying the job elements of the Position Analysis Questionnaire (PAQ) (Tech Rep. 4). Lafayette, IN: Purdue University, Occupational Research Center, June 1974.

This study is concerned with the identification of the job dimensions underlying the job elements of the PAQ (Form B), which is a structured job analysis instrument consisting of 187 worker-oriented job elements divided into six dimensions. The dimensions identified are based on a representative sample of jobs.

personality variables and achievement measures, but not with job behavior. The procedures used to support the existence of the 120 abilities are too flexible to be conclusive.

Gustafson, H. W., Honsberger, W. D., & Michelson, S. Determination of task analysis content. In Uses of task analysis in deriving training and training equipment requirements (Tech. Rep. 60-593). Wright-Patterson Air Force Base, OH: Wright Air Development Center, December 1960.

These authors believe that the content of task analysis cannot be widely generalized from problem to problem. They argue that although a universally applicable task analysis format can never be attained, a generalizable task analysis procedure can be derived. They consider the decisions that have to be made about the design of training and training equipment for a specific system, and list questions about task attributes that have to be addressed prior to decision making. In practice the method has had only limited success, but justifies further scrutiny.

Hammel, T., Sroka, F. P., & Allen, F. L. Study of training device needs for meeting basic officer tactics training requirements. Groton, CT: General Dynamics, Electric Boat Division, March 1971.

A diagramming method called link analysis is applied to portray communication links between team members during the conduct of mission activities. These diagrams convey either the strength (importance) or frequency of the communications.

Hughes, J. A., & Hymes, J. P. A study of the effectiveness, feasibility and resource requirements of instructional systems development: EA-6B readiness training (Tech. Rep. 75-C-0100-1). San Diego: Courseware Incorporated, January 1977.

Courseware, Inc. has developed a process of analyzing the human functions performed in a system into constituent major tasks. A listing of the tasks performed by each member of a team is developed. These listings serve as the foundation for subsequent system analysis efforts. Relationships among tasks are represented in a standard format which is sufficiently flexible to allow changes that require minimal reorganization. The task lists are derived by first having subject matter experts describe a step-by-step account of a mission. Instructional psychologists and technologists work with the expert in more formally defining the tasks performed during conduct of the mission.

Hunt, E. We know who knows, but why? In R. C. Anderson, R. J. Spiro, & W. E. Montague (Eds.), Schooling and the acquisition of knowledge: Conference proceedings (NPRDC Tech. Rep. 78-6). San Diego: Navy Personnel Research and Development Center, December 1977.

Some of the implications of individual differences in information processing are considered. It is possible to predict the ability of an individual to acquire new knowledge. Since knowledge builds on previously acquired knowledge, small differences in information processing can multiply into large differences in acquired knowledge. A model of linguistic information processing--the Carpenter and Just constituent comparison model--is presented, and research findings on individual differences in reaction time are used to explain learning differences in terms of the model. Three areas requiring more research are presented: (1) How do information processing measures relate to each other? (2) What strategies are used by skilled problem solvers in selecting pertinent information and generating alternate representations? (3) How do the relative contributions of information processing and knowledge change as the tasks and the subjects change? The

4. Instructions on what information to obtain, how to get it, and where and how to record it.

5. Examples of completed portions of a task analysis.

This report also presents a theory showing the relationship between the required task data and the training requirements determined from that task data.

French, J. W. Toward the establishment of non-cognitive factors through literature search and interpretation (Tech. Rep. 1). Princeton, NJ: Educational Testing Service, July 1973.

This report describes one study in a series involving the conceptualization of ability and temperament factors and the development of measures of these factors. This particular study was a literature review of temperament factors: Twenty-eight factors selected from the literature were not empirically tested.

Gibbons, A. S., & Hughes, J. A. A method of deriving hierarchies of instructional objectives. Proceedings of the Human Factors Society 22nd Annual Meeting, Detroit, October 1978, 256-259.

The establishment of objectives hierarchies by analysts has been very subjective and nonuniform. The procedures presented herein are intended to enable the inexperienced analyst to develop logically consistent objectives hierarchies. These hierarchies are constructed by first obtaining task lists then subjecting these tasks to finer analysis, and, finally by using a set of rules to transform these subtasks into instructional objectives in an orderly fashion. Tasks are listed at levels of detail sufficient for performance standards and conditions to be specified. Subtasks are then classified as either classification and rule-using or motor control. Verbal support requirements for each subtask are identified. In addition, minor subtasks are grouped in a way that provides meaningful instruction for the group, when separate instruction for each would not be appropriate. Those minor subtasks that cannot be grouped are dropped from the list of tasks to be trained. Tasks that are too expensive or too dangerous to train are eliminated. Finally, for those subtasks that might require nonstandard procedures in special situations, an analysis of the knowledge base is performed to provide performance guidelines. The analyst performs each of the nine steps for each task in the task list. Through this procedure, patterns of complex behavior and their enabling objectives are identified. These patterns identify prerequisite instruction to task performance. These methods are intended to guide the thoughtful analyst and ensure that some minimal considerations are made.

Goodyear Aerospace Corporation. Study of submarine casualty control training (Tech. Rep. 1813-1). Port Washington, NY: Naval Training Device Center, March 1966.

This approach is used to analyze casualty data. It attends to crew responsibilities, conditions, and performance, and provides an analysis of casualty sequences for a particular system. Information flow diagrams are used to represent a linear analysis of information flow relative to a specific system. The information flow does not key on particular individuals processing the information.

Guilford, J. P., & Hoepfner, R. The analysis of intelligence. New York: McGraw-Hill, 1971.

Guilford's research on intellectual abilities is summarized and his model of the structure of abstract cognitive abilities is presented. The abilities are correlated with

Fleishman, E. A., Kinkade, R. G., & Chambers, A. N. Development of a taxonomy of human performance: A review of the first year's progress (Tech. Rep. 1). Washington, DC: American Institutes for Research, November 1968.

This report reviews the first year's progress of a 5-year project to develop and verify the utility of a taxonomic system of human task performance. It is organized into four areas: the review of previous taxonomic efforts, the development of an integrative model, the proposal of a provisional classification scheme, and the definition of requirements for a human performance data base. There are no empirical findings and, as the report covers the first year of a 5-year project, the utility is only projected.

Fleishman, E. A., & Stephenson, R. W. Development of a taxonomy of human performance: A review of the third year's progress. Washington, DC: American Institutes for Research, 1970.

This report is of the third and final year of what was originally a 5-year project. Only brief examples are given of the constructed task assessment scale (describing tasks), the task characteristics rating scales, information theory categories, definitions, and data base categories. Empirical findings are not reported.

Fleishman, E. A., Teichner, W. H., & Stephenson, R. W. Development of a taxonomy of human performance: A review of the second year's progress. Washington, DC: American Institutes for Research, 1969.

Three provisional approaches (each relevant to one user type) to performance taxonomy are developed: ability requirements, task characteristics, and systems language approaches. Classifications are made in terms of 37 human abilities, 24 task characteristics and 7 types of information processing constraints. Taxonomies are not validated or utilized.

F.M.C. Corporation. MICV/TBAT-II, human factors engineering progress report, sequence AD 17, DI-H-1314 (Tech. Rep. DAAK 30-77-C-0002). San Jose, CA: May 1977.

F.M.C. Corporation devised a task sequence analysis approach in which the major functions and tasks performed by system personnel are identified and, then, sequentially ordered. A system mockup is developed and used by subjects in a series of trials. The subjects perform a series of tasks described in a written script. Human factors personnel observe these trials and record time, duration, and position of subjects during task performance. These data are then used during further refinements in the training system development process.

Folley, J. D., Jr. Development of an improved method of task analysis and beginnings of a theory of training (Tech. Rep. 1218-1). Orlando: Navy Training Device Center, June 1964.

The objective of this study was to devise an effective method of task analysis that would fit in with a larger program of training device development. The guidelines for task analysis that were defined include:

1. Background materials thought to be useful to the task analyst.

2. An overview of the process of task analysis.

3. Samples of forms to be used in task analysis.

development process because they relate to the content of a job, associated tasks and duties, mission requirements, equipment and supporting materials, allocation of man-machine functions, operator capabilities, and other general personnel policies, concepts, and manpower forecasts. Therefore, the personnel information becomes a characterization of a particular job and its associated responsibilities.

Demaree, R. G., Norman, D. A., & Matheny, W. G. An experimental program for relating transfer of training to pilot performance and degree of simulation. (Tech. Rep. 7619-1). Fort Worth: Life Sciences, 1965. (AD-471 806)

Training equipment requirements data are gathered to generate functional requirements for a training situation. Operational tasks are analyzed into training function statements of what the trainee needs to know. Each training function is then divided into discrete tasks and fidelity requirements are derived. Finally, performance standards are established for each task. Considerations of trainee characteristics, training context, equipment requirements, and instructor requirements are all taken into account.

Department of the Air Force. Handbook for designers of instructional systems, Volume II (Tech. Rep. 50-58). Washington, DC: Author, July 1973.

The handbook consists of five volumes and addresses the development of instructional systems. The volumes include: introduction task analysis; objectives and tests; planning; developing and validating instruction; and evaluation. In Volume II, task decision worksheets are provided to record task information. The statement includes identifying information, training factors, and task activity factors. The format can be an outline, a flow chart, a table, or a time line. This document is a forerunner to the ISD model.

Ekstrom, R. B., French, J. W., & Harman, H. H. Problems of replication of seven divergent production factors (Tech. Rep. 5). Princeton, NJ: Educational Testing Service, May 1974.

This study, which is one of a series of ETS studies on the development of measures of cognitive ability and temperament factors, was concerned with the development and evaluation of factor references or markers of divergent production. There is little evidence that the measures developed are related to the job performance.

Ekstrom, R. B., French, J. W., & Harman, H. H. An attempt to confirm five recently identified cognitive factors (Tech. Rep. 8). Princeton, NJ: Educational Testing Service, June 1975.

This paper describes five newly-established cognitive abilities (concept attainment, figural fluency, integrative processes, visual memory, and verbal closure) identified as part of an ETS project concerned with developing measures of abilities and temperament factors. Each of these abilities was tested and analyzed for validity.

Engel, J. D. An approach to standardizing human performance assessment (HumRRO Prof. Paper 26-70). Alexandria: Human Resources Research Organization, October 1970.

Two areas of importance in the standardization and evaluation of methods to assess performance are task classification and performance measurement classification. This report describes these areas and reviews earlier taxonomic approaches. A four-category taxonomy is developed and an example is presented which tries to relate the task and performance measurement classifications.

Chambers, A. N. Development of a taxonomy of human performance: A heuristic model (Tech. Rep. 4A). Washington, DC: American Institutes for Research, October 1969.

The paper begins with an evaluation of performance taxonomies in the behavioral sciences. A model for the analysis of the issues involved in classifying human performance is presented. The paper concludes with a set of recommendations for developing a behavioral taxonomy.

Chenzoff, A. P., & Folley, J. D., Jr. Guidelines for training situation analysis (TSA). Valencia, PA: Applied Science Associates, 1965. (AD-472 155)

The Chenzoff and Folley approach involves a multistage method for task analysis. First is a system block analysis, which is a flow chart of the major blocks of tasks or system operations that are all directed toward attaining a system goal. Then task-time charts are prepared to identify each task in a block, the appropriate operator, time for completing events in the block, time for each task, and coordination required among the tasks. Adverse conditions affecting task performance are also specified. During the functional task description phase, the typical and maximal allowable times for task completion are identified. Tasks are broken down into major functional activities with time estimates for each. The behavioral-details description identifies psychological characteristics and contributes more detailed information. At this stage, functional training requirements can be defined.

Cream, B. W., Eggemeier, F. T., & Klein, G. A. Behavioral data in the design of aircrew training devices. Proceedings of the Human Factors Society's Nineteenth Annual Meeting, Dallas, October 1975.

This paper addresses the applicability of task analysis information in the design of training devices. For relatively simple tasks to be trained, detailed task analysis data (as in ISD) are sufficient to design an appropriate trainer. This analysis provides a task list with subtasks, conditions, cues, and standards specified. In addition, crew coordination requirements, if any, are indicated. For more complicated tasks, however, such task analysis is not useful and may be misleading. Task analysis data cannot adequately define these tasks. To develop a training device for these more complicated tasks, one needs to conduct indepth interviews and empirical performance studies wherein cues, controls, and conditions are systematically altered. In this way, both the necessary and sufficient trainer requirements may be identified.

Dawis, R. V. A model, method, and taxonomy for the selection of tests as predictors. Minneapolis: Minneapolis Civil Service Commission, 1977.

Dawis describes a taxonomy of skills to be used for employee selection and proposes that for selection, skills should be analyzed into component abilities only. He uses a taxonomy as a guide to identify all the relevant abilities in each skill. As the model is meant to be applicable to all job related skills and abilities, no specific skills are mentioned. One of the major advantages of this model is that it links performance, skills, and abilities.

Demaree, R. G., & Marks, M. R. Development of qualitative and quantitative personnel requirements information (MRI-TDR-62-4). Wright-Patterson Air Force Base, OH: Behavioral Science Laboratory, 1962.

This report describes the nature, purpose, and method for developing personnel requirements information. These descriptions form an integral part of the total system

Ammerman, H. L. Systematic approaches for identifying and organizing content for training programs. Alexandria: Human Resources Research Organization, June 1970.

Experienced job incumbents are interviewed and asked to describe their activities on the job. A task list is generated from the responses of the incumbents. The key to this technique is the sophistication of the interviewer. This process is especially difficult to apply to nonprocedural jobs and jobs not directly oriented to hardware operation or maintenance.

Austin, H. A. Computational view of the skill of juggling. Cambridge: Massachusetts Institute of Technology, Artificial Intelligence Lab, 1974.

In this study the paradigm used in computer models of artificial intelligence was applied to the physical skill of juggling. Three taxonomies were developed on the basis of similarity in observed behavior--behaviors, errors, correction of errors.

Bernstein, B. R., & Gonzalez, B. K. Learning, retention, and transfer (Tech. Rep. NAVTRADEVCEN 68-C-0215-1). St. Paul: Honeywell Systems and Research Division, September 1969.

This study was primarily concerned with establishing research strategies in learning, retention, and transfer (L, R, and T) for improving naval training. Five planning activities fed into the formulation of the research strategy: (1) A brief review of relevant literature, (2) selection of an appropriate taxonomy of tasks, (3) survey of Navy jobs to determine critical tasks from a training standpoint, (4) organization and management of technical meeting with consultants, and (5) a conceptual design for a general purpose L, R, and T apparatus. Of a secondary nature, the study also concerned itself with the design and conduct of two initial experiments to provide a data base for subsequent investigations.

Campbell, S. C., Feddern, V., Graham, G., & Morganlander, M. A-6E systems approach to training. Orlando: Naval Training Equipment Center, February 1977.

This report discusses the use of mission scenario task lists, which are aids for generating task descriptions specifically for the performance requirements of an operational environment. A hierarchy is established for describing operator behaviors during a typical mission. Each phase of a system mission is defined in terms of major events, tasks constituting each event, and the steps describing the actions required by an operator to complete each task. Mission flow charts are used to pictorially represent a mission. The three levels of analysis are represented in the mission flow chart.

Caro, P. W. Equipment-device task commonality analysis and transfer of training (Tech. Rep. 70-7). Alexandria: Human Resources Research Organization, 1970. (AD-709 534)

Caro describes the stimuli and responses elicited by task elements and hardware in the operational equipment. Both hardware (displays and controls) and nonhardware (environmental) stimuli are considered. Parallel analyses are conducted of stimulus and response elements in a training device. By comparing the two lists, the critical stimulus components are identified and predictions about device effectiveness can be made. Caro refers to his method as task commonality analysis.

items must approach the weapon system equipment in level of fidelity. By requesting data limited to the appropriate breadth and depth, considerable cost benefits can be realized. The data guide helps the project manager overcome these data-related problems in a systematic, procedural manner. Suggested data delivery schedules presented key delivery and/or availability of data to prime contract preliminary design reviews (PDRs) or critical design reviews CDRs) to ensure adequate maturity of data and to minimize the risk of changes to the weapon system.

Williams, J. D., Zinke, R. A., Hardie, E. E., Kahl, J. S., Sharpe, L. G., Sink, M. F., & Vandergaag, M. Personnel subsystem testing in the man-computer environment. A case study. Proceedings of the Human Factors Society 19th Annual Meeting, Dallas, October 1975, 186.

The development of new man-computer systems at Bell Telephone Laboratories includes both computer subsystem and personnel subsystem (PSS) design efforts. There has been little information in the literature to provide the designer with guidelines and procedures for testing PSS. Bell Laboratoaries Human Performance Technology Center has developed a series of testing procedures to provide useful performance data to PSS designers and training development. Only an abstract is provided in the Human Factors proceedings.

Training Subsystem[1]

Task and Skill Analysis

Aerospace Medical Division. Uses of task analysis in deriving training and training equipment requirements (Tech. Rep. 60-593). Wright-Patterson Air Force Base, OH: Author, December 1960.

This report includes a series of papers on task analysis presented at an Air Force sponsored conference. Descriptions of the following approaches to task analyses are included: information-decision-action chart, operational sequence diagram (elsewhere discussed), and task-equipment analysis. The information-decision-action approach characterizes tasks in terms of information/decision/action units. Scenarios are presented on charts that convey verbal accounts of activities occurring during each unit. The charts themselves portray tasks performed by an operator or group of operators. If there are multiple operators, relationships in time and activity are depicted. In the task-equipment analysis approach, tasks, personnel, equipment display, decisions, actions, and feedback are represented in a matrix that allows the criticality of displayed information to be evaluated.

Amberson, M. L., Bishop, D. D., & Agoes, B. Competency commonalities and accompanying job titles derived from the six Montana agriculture manpower studies. Bozeman, MT: Montana State University, Montana Agricultural Experimental Station, June 1975.

The purpose of this project was to determine the nature and opportunities in agribusiness and farming in order to develop a curriculum that would prepare Montana youth to meet these job requirements. The taxonomy developed, which is relevant to education rather than to the job, involves an undifferentiated mix of skills, attitudes, and behaviors.

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[1]This literature review was facilitated by several existing literature reviews listed in Appendix B (e.g., Bownas and Cooper, 1978; Chenzoff, 1964; Dunlap and Associates, Inc. 1978; Montemerlo & Tennyson, 1976; Smith, 1969; and Wheaton, Rose, Fingerman, Karotkin, & Holding, 1976).

power trade-off determination and review, and ensure that manpower/training information flow is timely and correctly channeled.

Singleton, J. W. The man-machine paradigm in large information processing systems: The process of command control system design. In J. E. Uhlaner (Ed.), Psychological research in national defense today (Tech. Rep. S-1). Washington, DC: U.S. Army Behavioral Science Research Laboratory, June 1967.

The methodology applied to assure effective control design in military command control systems is discussed and amplified. The three components of a command control system must be controlled during development: facilities, hardware, and software. The stages of the system engineering development cycle and the output expected at each stage (such as the advanced planning stage that establishes objectives or the system performance description that achieves a functional description of the operating system) are reviewed. A schematic diagram is presented that integrates the components of hardware, software, and facilities with the stages of the system engineering development cycles to ensure that the operating command control system meets the information needs of the using military command.

Sugarman, R. C., Johnson, S. L., & Hinton, W. M., Jr. SAT revisited--A critical post-examination of the systems approach to training. Proceedings of the Human Factors Society 19th Annual Meeting, Dallas, October 1975, 271-273.

The systems approach to training (SAT) applies the techniques of systems analyses to instructional system development to ensure the consideration of the entire training system including time and external constraints. SAT is a conceptual framework. A model of an information flow hierarchy is presented. The strengths of SAT such as relevance, internal documentation, economy, and the potential problem areas, including the ability of the training analyst and the need for creativity and innovation, are discussed.

USAF 3306 Test and Evaluation Squadron, Mission Handbook. Edwards Air Force Base, CA: Author, June 1977.

The mission of this squadron is to develop system-specific maintenance training programs and training equipment requirements. This mission is achieved by implementing instructional system development (ISD) methods. The particular way these methods are applied by the 3306th is the subject of the handbook. The procedures described are intended to maximize objectivity in decisions related to program development and derivation of equipment requirements. This is achieved through extensive use of procedural checklists and decision trees. Full documentation of decision factors ensures adequate justification of recommendations. The handbook is not a cookbook, but a means of reducing subjectivity and providing a common basis for decisions.

U.S. Army Project Manager for Training Devices (PM TRADE). Project Manager's Training Device Data Guide, Volume 1. Orlando: Author, September 1978.

The data guide was developed to provide weapon system project managers with a method for facilitating concurrent development of the weapon system and training device(s). Two major problems associated with concurrent development are the inability to specify the type and amount of data necessary for training device development and the lack of contract procedures for ensuring that data are provided to the training device contractor in a timely manner. Data can be limited in two ways: in breadth by requesting data for only those weapon system equipment items to be represented in the training device, and in depth by determining the degree to which the training device equipment

4. Identification of potential perturbing events (literature search, interview data, contractor base, intuition of study team).

5. Categorization of events by probability, according to the judgment of survey participants (queried by questionnaire).

6. Examination of potential effect of probable events upon extrapolated trends to produce a surprise-free scenario of the NAVAIR environment 1985-1995 (interview data, panel discussions, structured workshops, judgment of study team).

Neiswender, L. Maximizing your training efficiency: The application of behavioral principles to job training. Washington, DC: U.S. Department of Labor Manpower Administration, November 1972.

This training manual is designed to instruct work supervisors and skills trainers of the hard-to-employ disadvantaged in the effective use of behavioral reinforcement principles for overcoming difficult, frequently encountered training problems. One of its primary focuses is how to train for job-required behavioral skills such as punctuality or taking criticism.

Parsons, S. O., & Lebach, J. L. The standardization of human factors data. Human Factors, 1970, 12, 55-62.

Although the success of the Apollo Applications Program requires the close integration of human factors documentation, human factors data are developed piecemeal in its early phases. The objective of this study was to develop standard human factors reporting techniques compatible with computer data processing methods. Thirty-two human factors data forms and techniques were analyzed. A matrix was developed that organizes 17 document and data types by 43 specific content areas. Representatives from the six user organizations indicated the needs of their organization in performing specific design and development functions. High frequency data items formed the basis for developing a single format that can be applied to any new manned system.

Porter, E. H. A paradigm for system analysis of command and control functions. In J. E. Uhlaner (Ed.), Psychological research in national defense today (Tech. Rep. S-1). Washington, DC: U.S. Army Behavioral Science Research Laboratory, June 1967.

The traditional stimulus response paradigm is discussed. A model is illustrated that outlines the functional relationships and dynamic interrelationships found in most systems, and applies this model to an air-defense command control system.

Ruland, J. K., Akman, A., Ettlinger, L., Kramer, H., Luhring, R., & Peterson, F. Military manpower versus hardware procurement study (HARDMAN). Washington, DC: Office of the Chief of Naval Operations, February 1977.

This is the final report of a 10-month study to analyze the definition of manpower-- training requirements during the Weapons System Acquisition Process (WSAP). The authors conclude that manpower/training considerations occur too late in the WSAP and, in many cases, receive too little attention relative to hardware development effort. Recommendations to improve this situation so that manpower/training factors would receive adequate consideration at appropriate times in the WSAP include: Establish a HARDMAN Project Office to oversee addressing of manpower/training issues appropriately, develop manpower/training forecasting models to assist in early requirements definition, implement manpower/training cost and trade-off models to assist in hardware/man

conclusion that ISD approaches cannot be successfully used by the layman to replace an experienced training development analyst. He suggests that further research emphasize development of ways to assist rather than replace the expert training developer.

Naval Weapons Engineering Support Activity. A prediction of aviation logistics requirements for the decade 1985-1995. Washington, DC: Author, June 1978.

Methodology used to forecast Navy logistical support rests heavily on the "informed judgments" of 200 representatives from industry and government. The following questions are addressed:

1. What do we want our position to be in the year X?

2. What will our position be in the year X if present trends continue?

3. What is likely to happen before the year X to perturb present trends, and what will be the effect?

4. What discrepancies exist between this probable future and the desired one?

5. What options do we have which may reduce these discrepancies?

6. What policy can we follow to enhance the probability of achieving our desired position in the year X?

All the many various forecasting techniques are designed to address one or more of these questions. In the jargon of technology forecasters, the answer to question 1 constitutes a normative forecast; question 2 results in a baseline scenario; question 3 identifies external events that will act upon the baseline scenario to produce a surprise-free scenario. The gap analysis conducted in response to question 4 is followed by the exploration of alternative scenarios consequent upon the occurrence of other planned/unplanned events (question 5) to determine their effects upon the identified discrepancies. With these data, policy makers can make an informed selection of the available options (resource allocation, mission formulation, equipment buys, etc.) (question 6) to maximize the probability of achieving their goals.

In addition to the individual interviews, the following additional activities were used: problem definition/analysis, literature search, data analysis, structural questionnaire soliciting estimates of key-event probabilities distributed to informed military/industrial personnel, general panel discussions with selected expert military/industrial personnel, panel data analysis, structural impact prediction exercise with selected expert military/industrial personnel, data synthesis and formulation of findings, distribution of findings, and continuing review, analysis and refinement of findings by study team.

Initial intuitive conclusions were verified using the following established techniques of technological forecasting:

1. Identification of a set of descriptors (i.e., economic and technologic trends descriptive of the NAVAIR environment) as a result of the literature search, interview summaries, and the judgments of the study team.

2. Cumulation of historic values for these trends over as long a time period as possible (literature search, contractor data base, personal discussions).

3. Mathematical extrapolation of these trends through 1995.

Maintenance Training (Transforming High School Graduates into Sonar Engineers). Training for sonar maintenance has received greater attention than training for sonar operations. Nonetheless it is doubtful whether the average crew of technicians can keep today's sonar systems in peak operating condition. It may be necessary to develop technician-engineers who can solve maintenance problems on a systems level for complex systems such as the SQS-26 and BQS-13 sonars. The report lists related recommendations from the previous ASWAC study.

ASW System Design and Human Engineering Considerations. The trend toward designing ever more complex and large sonar systems has resulted in a corresponding inclination of reducing the role of personnel to simple monitors of automatic systems. The report recommends that greater attention be devoted to the trade-offs in function allocation between man and machine. Where automatic functions are introduced, they should be clearly related to the most likely areas of human failure. The needs of the system should be more carefully analyzed and assessed from the standpoint of operator use and effectiveness. A data base should be developed for maintaining a historical appraisal of the capabilities and deficiencies of sonar systems. Related recommendations from a previous ASWAC study are listed and evaluated.

Miller, L. A., McAleese, K. J., Erickson, J. M., Klein, G. A., & Boff, K. R. Training device design guide: The use of training requirements in simulation design (F33615-76-C-0050). Wright-Patterson Air Force Base, OH: Air Force Human Resources Laboratory, June 1977.

This guide provides a process for the design of trainers based on behavioral information. Behavioral information includes task analyses, training requirements, training scenarios, perceptual (display/control) requirements, malfunction/problem scenarios, and other information that has freqently been ignored when developing simulation designs. The guide outlines the information requirements of trainer development personnel and presents a series of guidelines (e.g., checklists, flowcharts, and examples). Simulation fidelity and instructional features of trainers ai considered in some detail. The use of a design team to ensure that appropriate people get the information needed to make the right decisions is recommended. This guide is intended as an aid to trainer development and not an algorithm.

Montemerlo, M. D. Instructional systems development state of the art and directions for the future. Proceedings of the 8th NTEC/Industry Conference, Orlando, November 1975, 421-429.

Instructional systems development (ISD) approaches may be seen to be models of expert training program developers. The paper investigates the extent to which ISD methods in general can be used by laymen to replace the expert developer. The success of ISD is related to the degree that procedures for selecting and implementing optimal instruction can be devised. After a literature review, the conclusion is that there is no theoretical basis for development of algorithms to generate instructional programs. Examining the experiences of those who have attempted use of ISD, Montemerlo found that personnel require some training to apply ISD correctly. Close supervision by an experienced training developer was also required in some cases. It is unrealistic to think that one ISD model can solve all training development problems, since large variations of ISD methodology are required by different content areas. Current ISD approaches are utilized for not including all the necessary steps and for not including sufficient detail to perform some steps. Also, ISD models fail to specify skill and knowledge required of the ISD user. Some of the political, innovative, creative, managerial skills and technical knowledge that seems to be required are suggested. These considerations lead to the

to "top drawings" of training program sequences in an engineering fashion. Finally, a training control monitors the training development/production activity in much the same way as an engineering change control would to incorporate updates of requirements and scheduling. Although some issues still need to be resolved (e.g., skill level specifications and media selection criteria), the author maintains that the approach works and that standardizing and cataloging of behavior should begin.

Mackie, R. R. Personnel, training and human factor problems relating to ASW effectiveness. Goleta, CA: Human Factors Research, February 1970.

The objective of this study was to examine the impact of the Navy's current policies on ASW systems performance with respect to the selection, training, and utilization of ASW personnel, and from the standpoint of the design of the ASW systems for human use. Recent trends in training and systems design are emphasized. Each of the five main sections in this report deals with a major problem area.

Career Pattern and Training of the ASW Officer. The U.S. Navy still depends primarily on the "well-rounded" general purpose line officer for the operation, maintenance, and tactical employment of the most complex ASW systems ever developed. There appears to be no clear evidence of the Navy encouraging a career pattern that might lead to ASW specialists. Only 8 weeks of formal training are given to ASW officers, the majority of whom have no shipboard experience. Many students lack technical background. This report recommends that the Chief of Naval Personnel develop a career pattern for ASW officer specialists and conduct a detailed study of the knowledge and performance requirements of officers with ASW responsibilities to determine the depth of instruction required for the effective performance by officers in all stated responsibilities. It records and evaluates related recommendations from a previous ASWAC study.

Selection and Retention of ASW Personnel. This section includes the results of a Navy survey of the motivational factors influencing career decisions for the military source. The conclusions of the "Pride Board" report (OPNAV NOTICE 3500, OP-09B83, Ser 3191P09B8, dated 18 December 1961) are still valid. This report recommends that (1) an ASW officer career ladder be established that ensures promotion on the basis of demonstrated competence in ASW; (2) ASW departments be established aboard all ships having ASW as their primary mission and the secondary missions of ASW ships and aircraft be limited; and (3) all ASW teams be maintained as integral units at least until minimum standards of readiness have been demonstrated. Six recommendations from the previous ASW study are reported and evaluated.

ASW Team Training (Questions of When and Where). Since WWII, there has been a pattern to reduce training at sea and increase training ashore using ASW simulators. Operational training, for the purposes of this report, includes both the training of individual ASW personnel and of the ASW team. The most complex and demanding tasks confronting ASW sensor operators are those relating to target detection and classification. These are the areas in which shore-based training is weakest. The report supports efforts directed toward the definition of operational training requirements and operational training devices for all systems with a reasonably long life expectancy. It recommends that the opportunities for practice in operating techniques and realistic detection and classification capabilities be included in shore-based team trainers. It recommends defining the responsibilities of the school and the fleet clearly for each training requirement. It reports and evaluates related recommendations from a previous ASWAC study.

After the training environment has been specified for each training objective, a syllabus is generated. Each syllabus block is specified as a set of training objectives to be taught in a common time period in the same training device. The specific environmental characteristics necessary to train the syllabus block can then be determined by adding up the environmental characteristics for each training objective. Blocks that require similar training environments can be defined as involving the same training device. The essential environmental characteristics of the training device can then be translated into functional specifications with the assistance of training device designers.

This approach is intended to ensure that the essential environments in which the student must be trained, exist in at least one device. Additionally, only those environments that are necessary will be identified. Finally, a trade-off analysis of device features between different training devices can be conducted to ensure that each device is adequately utilized. A potential criticism of this procedure is its reliance on expert judgment to determine the necessary environmental characteristics for each training objective. The stated advantage of this approach is that these judgments are being exercised on relatively small training units, as opposed to decisions based upon the training of the overall task. This approach also recognizes the strong interdependencies between course design and resource requirements.

King, W. J., & Tennyson, M. E. Maintenance training and aiding in the 1980's: A prediction. Proceedings of the First International Learning Technology Congress and Exposition on Applied Learning Technology, Volume IV, Washington, DC, July 1976, 40-43.

At present, a significant portion of the DoD budget is allocated to maintenance training; at the same time, little is spent on research to improve the quality of this training despite the growth of increasingly complex equipment to be maintained. The paper focuses on using simulation and aiding for improving the maintenance of future weapon systems. In considering current aspects of training and aiding, it concludes that some form of mixing of the two, "traiding," would need to be continued into the foreseeable future. The Naval Training Equipment Center concept of modular integration of training information by a performance aiding computer (MITIPAC) is seen to offer a solution for future needs. Although the use of automated test equipment in the future modifies the nature of maintenance, maintenance training is still a major consideration. Finally, implications of the Navy Enlisted Occupation Classification System (NEOCS) are examined. According to NEOCS, major individual training expenses would be deferred until after the individual has made a commitment to remain in the Navy for an extended time. Exportable, individualized training via MITIPAC along with on-the-job training are considered as viable ways to obtain productive output without prior expensive training courses.

Klemmer, A. Training: An engineering process. Proceedings of the Sixth Naval Training Equipment Center and Industry Conference, Orlando, November 1973, 449-459.

The author argues for adoption of an engineering approach to the development and management of training programs. To indicate the feasibility of this, the approach taken by Douglas Aircraft Company's Military Training Department is briefly described. It is pointed out that the procedures used by Douglas parallel engineering hardware develop-ment activities. Key to the training program is the establishment of Training Instruction Requirement Specifications (TIRS) numbers which course planners would use as engineers would use part numbers to design a piece of equipment. TIRS numbers specify: method of instruction, media to be used, prerequisite instruction, time estimate, instructional objectives for course planning, and student behavioral objectives. These TIRS are applied

Merrill, P. F. Task analysis: An information processing approach (Tech. Memo. 27). Washington, DC: Office of Naval Research, April 1971.

This study proposes and describes an information processing approach to task analysis. A learning task may be analyzed at two levels: a task level concerned with subskills required to learn and perform a terminal objective, and a rule level entailing the most effective instructional method for teaching subskills. This report focuses on the task level. It contrasts information processing and hierarchical task analyses models and concludes that neither approach is sufficient for all tasks. Hierarchical analysis is more appropriate for lower ordered skills, while information processing analysis should be used when the output of one task subskill is required input for a succeeding operation.

Meyer, R., Laveson, J., Weissman, N., & Eddowes, E. Behavioral taxonomy of undergraduate pilot training tasks and skills: Taxonomy refinement, validation, and operation. St. Louis: Design Plus, December 1974.

This report describes a program concerned with analyzing the fundamental tasks involved in undergraduate pilot training. The goals of the program were to determine the flying skills and behavioral elements involved in flying and to develop a taxonomy relating tasks, skills, and behavioral elements. Flying tasks are analyzed into one of three types: fundamental, composite, or continuous. Because the classification system is easy to use and requires only a knowledge of flying, it shows great promise for use in training and evaluation. The approach used in developing this taxonomy is more sophisticated than that used in most taxonomies.

Miller, R. B. A method for man-machine task analysis (Tech. Rep. 53-137). Pittsburgh: The American Institute for Research, June 1953.

An operational situation is broken down into missions. For each mission a time chart is prepared that lists tasks and then groups them as functions of time, similarity of skill, or equipment requirements. Both time continuity and time sharing are considered. The procedure is as follows. In the first step, gross tasks are identified and the input features of each task are analyzed by addressing task-relevant cues for initiating task performance, stimulus differences for discrimination, alternative choices, and characteristic errors for malfunctions associated with the task. The second step involves the analysis of subtasks with emphasis on the response aspects of a task and addresses similar features, as well as identifying feedback mechanisms and objective criteria for assessing adequacy of response.

Miller also addressed the task analysis of continuous feedback tasks. He describes the skills involved in making continuous adjustments to changing stimulus conditions and reactions to operator adjustments. Attention is focused on controls, displays, and the feedback mechanisms.

Miller, R. B. A method for determining task strategies (Tech. Rep. AFHRL-IR-74-26). Pittsburgh: American Institutes for Research, May 1974.

Ths study is an extension of Miller's task analysis methodology. The concept of strategic principles or task strategies implicit in the job activities of highly proficient performers is examined with the intent of improving training. The basic approach considers the human performer as an information processing system and describes unique features of skilled performance in information processing terms. A set of 25 terms associated with information processing are discussed. The set can more or less be grouped under the functions of input-processing-memory-output. A procedure for detecting or

inventing strategies that distinguish skilled from unskilled performance of a given task is outlined. In general, the process involves analyzing the job (including the general goal and major steps) in transaction (information processing) terms, and after some simplification, creating and testing a strategy that most adequately fulfills the criteria for the accomplishment of the goal or mission.

Mitchell, J. F., & Ramsey, T. A. B-1 systems approach to training task analysis listings. Buffalo: Calspan Corporation, July 1975.

Calspan developed a hierarchical method for organizing system information. The format of the task analysis data is initiation cue, action verb, control, and completion cue. The initiation cue consists of a combination of relational statements involving controls or displays, a connective, and value or state. The action verbs are standardized terms corresponding to the control that is operated upon. The control is the direct object of the action verb. In some cases a display can be operated on and becomes the control. The completion cue, which indicates the termination of a behavioral unit, may serve as the intiating cue for the next behavioral unit. Each behavioral unit is called a task element. Task elements are grouped to form tasks, which in turn are grouped to form functions. Mission segments are defined as groups of functions. Computer storage and retrieval are utilized in the Calspan approach.

Montemerlo, M., & Eddowes, E. The judgmental nature of task analysis. Proceedings of the Human Factors Society 22nd Annual Meeting, Detroit, October 1978, 247-250.

The notion that a best task analysis procedure exists is examined critically. There are many tasks for which the best way of doing them cannot be described. Other tasks, however, can be performed in a best way. Task analysis appears to be a task for which the best way it should be performed cannot be described. It is difficult to find two instructional technologists who agree on how to conduct a task analysis. Also, there are persons who can perform a good task analysis and others who cannot. The process of task analysis has not been amenable to task analysis.

The ability to proceduralize is inversely proportional to the degree to which a task is affected by other variables. This ability is also inversely related to the extent that one step influences others. If problem-solving behavior is involved, the task is difficult to proceduralize. The size of the domain of possible task behaviors also affects the ability to proceduralize a task. Interpersonal skills are hard to proceduralize (task analysis itself is an interpersonal skill). Tasks involving cognitive skills are difficult to proceduralize, because they are hard to make observable. Task analysis is highly loaded with cognitive skills. The scientific basis for task analysis is poor and, therefore, measures for task analysis are not well developed.

These factors indicate that task analysis is not reducible to a well-defined procedure. The historical way to learn a judgmental task, such as task analysis, is via apprenticeship training. Recently, the military has begun to be aware of the judgmental nature of task analysis and the fruitlessness of attempts at its proceduralization.

Munger, M. R. The study of training equipment requirements for tactical data systems, project memorandum #2: A systems approach to the determination of functional training equipment requirements. Pittsburgh: American Institute for Research, November 1959.

Munger's approach includes six major techniques: functional analysis (allocation of functions between man and machine and identification of gross tasks); skill and knowledge

analysis (determination of primary skill and knowledge requirements); task equipment analysis (specification of procedure and equipment), error analysis (identification of potential human errors); mission analysis (process of analyzing system missions); and contingency analysis (listing of nonroutine situations). This information is used in identifying tasks, determining stimulus-response features, identifying possible response errors, and specifying required training programs.

Parker, J. F., Jr., & Downs, J. E. Selection of training media (Tech. Rep. ADS TR 61-473). Wright-Patterson Air Force Base, OH: Aeronautical Systems Division, September 1961.

Parker and Downs discussed the translation of statements of desired personnel performances and capabilities and task analysis documents into training objectives. They identify three classes of simulation of the contextual environment. Extraneous contextual cues include general irrelevant-environment cues accompanying task performance. Performance degraders are forces that cannot be overcome to any appreciable extent by practice and tend to reduce performance capabilities in a relatively constant manner. Performance disruptors are forces that are disruptive at first, but can be overcome through practice. Therefore, while performance disruptors should be simulated, there is little benefit to simulating performance degraders.

Powers, T. E. Selecting presentation modes according to personnel characteristics and the nature of job tasks. Baltimore County: University of Maryland, January 1977.

The purpose of the study was to improve Navy technical manuals by finding a way to match user characteristics with manual characteristics. Although this report contains an extensive review of the literature on behavioral and task taxonomies, it is mainly concerned with the development of a questionnaire to measure the behaviors required for a number of technical jobs. The questionnaire was administered to 452 petty officers. Its results were used to develop a taxonomy of cognitive behaviors for technical jobs and to determine what information is appropriate to include in training manuals.

Rankin, W. C. Task description and analysis for training system design (Tech. Memo 74-2). Orlando: Navy Training Analysis and Evaluation Group, January 1975.

This report examines what constitutes task description and task analysis in the context of training system design. Task description is a physical description of tasks in the form of a task inventory. Task analysis is a behaviorally analytic description. The advantages and disadvantages of two approaches to task descriptive data collection—the interview and the questionnaire—are discussed. Selected current efforts in task description in the naval training community are reviewed, but not evaluated (ILDG, PQS, NOTAP, TAEG). The TAEG approach to task description is presented in an appendix, which includes an instrument (forms) for collecting task information and a primer of instructions for completing them.

Riccobono, J. A., & Cunningham, J. W. Work dimensions derived through systematic job analysis: A replicated study of the occupational analysis inventory. Raleigh: North Carolina State University, Center for Occupational Research, 1971.

This is part of a series of studies concerning the occupational analysis inventory (OAI), which is a quantitative system for describing and measuring work. The present study was to test the stability of the factors found in prior research with a sample of 400 new jobs.

Shettel, H. H., & Horner, W. R. Functional requirements for driver training devices (Tech. Rep. 86400 10/72-FR). Pittsburgh: American Institute for Research, 1972.

This approach identifies key learning elements, categorizes them according to type of behavior, identifies relevant training techniques, and arranges these techniques into training programs. Task analysis, which is addressed at a middle level (i.e., not too global or too specific), mainly identifies major behavioral events. For each task a definition of the task, including initiating cues and terminating events, and statement of prerequisite skills is provided. Difficult-to-learn or highly critical elements are also identified. An important addition is a rationale for training. From this information, appropriate strategies and techniques are identified. Further definition of learning objective, desired response, and feedback requirements are part of the overall analysis.

Siegel, A. I., & Federman, P. J. Increasing ASW helicopter effectiveness through communications training (Tech. Rep. NAVTRADEVCEN 66-C-004501). Orlando: Naval Training Device Center, October 1978.

Siegel and Federman used an "amount of intellectual operation" scale to rate the contribution of cognitive, memory divergent production, convergent production, and evaluation operations in the performance of a particular task. The method indicates which tasks impose the heaviest intellectual load and, therefore, require training. It also identifies the specific types of intellectual activity required. The approach is based on J. P. Guilford's structure of intellect model.

Theologus, G. C., & Fleishman, E. A. Development of a taxonomy of human performance: Validation study of ability scales for classifying human tasks. Washington, DC: American Institutes for Research, 1971.

This is a technical report of the AIR project to develop a human performance taxonomy. The Task Assessment Scales (TAS) were developed to operationalize the ability requirements approach to performance assessment. The scales of the TAS were tested both for construct validity and predictive validity.

Theologus, G. C., Romashko, T., & Fleishman, E. A. Development of a taxonomy of human performance: A feasibility study of ability dimensions for classifying human tasks. Washington, DC: American Institutes for Research, 1970.

This report describes the initial development of the Task Assessment Scales (TAS), a classification system based on ability requirements for performance.

Tornow, W. W., & Pinto, P. R. The development of a managerial job taxonomy: A system for describing, classifying, and evaluating executive positions. Journal of Applied Psychology, 1976, 61, 410-418.

This study attempted to replicate and improve Hemphill's research on managerial jobs. A questionnaire was developed to include items concerning managerial activities, concerns, responsibilities and demands, and tested empirically. This is one of the better empirical taxonomic studies.

USAF 3306 Test and Evaluation Squadron. Mission Handbook. Edwards Air Force Base, CA: Author, June 1977.

The 3306 Test and Evaluation Squadron (TES) is responsible for instructional systems development for the Air Force. TES has developed several forms to assist them in the ISD

process. One form is used to document and establish training requirements. If a valid training requirement is identified, required behaviors, conditions, and standards of performance are specified. Media requirements are also detailed in this statement. Another form is used in detailing maintenance instructions procedures when adequate data are not available. Constraining factors, resource requirements, and performance criteria are also defined.

Wheaton, G. R., Rose, A. M., & Fingerman, P. W. Methods for predicting job ability requirements: IV, Task characteristics, ability requirements, and problem-solving strategies. Washington, DC: American Institutes for Research, September 1975.

This report describes four studies designed to generate principles for identifying ability requirements from the task characteristics and the conditions. Most analyses of the abilities necessary to perform a task are based on task characteristics and not on the conditions under which the task is performed.

Willis, M. P., & Peterson, R. O. Deriving training device implications from learning theory principles, Volume I: Guidelines for training device design, development and use. Port Washington, NY: Naval Training Device Center, 1961. (AD-264 364)

Basic principles of skill acquisition and a detailed behavioral taxonomy were derived. These two dimensions were then related in a matrix by this approach. A task is analyzed into a task description, list of critical activities, and the behavioral categories required. According to the composition of skill and behavioral categories identified for a given task, particular guidelines for training are identified. Because the categories are rather subjective, this approach is relatively difficult to apply.

Media Selection Methods

Anderson, R. H. Selection of media: Another perspective. Improving Human Performance: A Research Quarterly, 1974, 3, 81-107.

The selection of instructional media is difficult, because it must be based on a combination of complex and interrelated factors such as degree of stimulus and/or response simulation necessary, hardware availability, cost-effectiveness, and need for media within the larger context of an overall training system. As the decision process now stands, there are very few guidelines available. Historical data on behavioral change through media use are imprecise. Cost figures are difficult to determine. Training requirements often specify the need for a particular medium within the requirements statement itself. A series of key decisions is suggested. Is one interested in information or instruction? Next, one must choose between instructional aids (media to aid live instructor presentation) and instructional media excluding live instructor. The third decision involves the characterization of content and distribution requirements. Finally, a particular category of media is selected. Flowcharts are developed to assist the user in decision making. Most of the media considered may be classified as communication media.

Boeing Company. Specification for the design, preparation, and submission of training and training equipment requirements. Seattle: Author, 1975.

Training media requirements should be selected to facilitate the specified learning types required to achieve behavioral objectives. The intent should not be to establish particular types of media, rather to identify media characteristics that training specialists can use as requirements in designing media and equipment. Media characteristics are

presented in five classes: visual/static, visual/static/aural, visual/dynamic, visual/dynamic/aural, and aural only. From these categories, more specific media alternatives may be identified. Boeing has prepared a handbook for the design of training and training equipment for Navy airborne weapon systems that presents a more detailed discussion of the topic.

Boucher, G. B., Gottlieb, M. J., & Morganlander, M. L. A selection system and catalog for instructional media and devices. Bethpage, NY: Grumann Aerospace Corporation, October 1971.

This report was developed for media selection decisons for the F-14 training system. An extensive computer data bank of media, media characteristics, and associated cost considerations was accumulated. The capability exists to list all media that satisfy a particular set of characteristics. A media-capabilites matrix of media types by media characteristics is the basis for the selection system. Each media-by-characteristic cell may be assigned one of a set of values depending on the degree to which that medium contains that characteristic. The process is carried out by first identifying the desired characteristics, and then determining which medium optimizes the fit. Data processing may be automated or manual.

Braby, R., Henry, J. M., Parrish, W. F., Jr., & Swope, W. M. A technique for choosing cost-effective instructional delivery system (TAEG Rep. No. 16). Orlando: Navy Training Analysis and Evaluation Group, April 1975.

This media selection approch involves three major steps: (1) redefining training objectives into appropriate learning algorithms, (2) choosing a set of instructional media that meet criteria for stimulus demands, training setting requirements, and administrative/budgetary constraints, and (3) applying cost estimates to each alternative media. The relative costs of alternatives is a major factor entering into the final decision to adopt a given media/media mix. All other things being equal, the least costly media are adopted for use.

The first step in applying the media selection method is to classify--and, thereby, match--each training objective into the appropriate one of 12 learning algorithms. In the next step the user consults one of 12 matrices appropriate to the algorithms selected for use in the training program. The rows of the matrix correspond to criteria required of media in order to successfully apply the instructional algorithm. The user selects from this extended list those criteria required for his particular situation. Columns of the matrix correspond to the different media that can appropriately be used in the instructional algorithm. The user selects only the media meeting all of the criteria for selection from this pool. Typically, two or more alternative media are selected in this way. The user then examines this reduced set of alternative media closely on the basis of 11 practical criteria such as budget cycle constraints, learning style of trainers, time to produce the system, etc. Based on this analyses additional media are eliminated.

Two things are worth mentioning about this part of the media selection procedure. (1) The range of media under consideration is extensive--from classroom lecture through simulators. This allows for systematic consideration of all alternatives. Selection of training devices is a possible output of this seleciton procedure. Many media selection procedures do not offer this alternative. (2) At this point in the process, formal detailed costing has not been performed; however, general cost factors are considered. The media selection charts contain a cost-selective decision point under administrative criteria. Also, cost related issues are raised in the test of practicality. These cost considerations can eliminate high-cost media which many media selection procedures cannot do.

The final step is the formal economic analysis of the remaining reduced set of media, which involves detailed cost estimates of facilities, equipment, instructional material development, personnel, supplies, and students. Application of a cost model in the analysis produces a present cost figure of each alternative media. The model is not intended to forecast total system costs, but to aid in media selection. The model does not provide a cost-benefit analysis.

Bretz, R. The selection of appropriate communication media for instruction: A guide for designers of Air Force technical training programs (Tech. Rep. R-601-PR). Santa Monica: Rand Corporation, February 1971.

Eight classes of communication media are identified: audio-motion-visual, audio-still-visual, audio-semimotion, motion-visual, semimotion, still-visual, audio, and print. It is important to note that all eight alternative media are telecommunications or recorded media. Each category of media is illustrated by relevant examples. A series of flow charts is provided to assist the user in selecting most appropriate medium for a given situation. By answering yes or no at each decision point, the user is directed to the appropriate media class.

Briggs, L. J. Handbook of procedures for the design of instruction. Pittsburgh: American Institutes for Research, 1970.

The Briggs handbook is oriented to the teaching of academic subjects in the classroom. Seventeen conditions of learning are identified and related to Gagne's eight types of learning. The 14-step procedure presented is highly dependent on a user's own relevant experience. Specific media categories are not specified. A designer is asked to choose media that meet criteria established by the conditions of learning and related stimulus characteristics.

Campbell, J. O., & Hughes, J. Optimizing media selection. Proceedings of the 11th NTEC/Industrial Conference, Orlando, November, 1978.

A procedure for selecting the optimum media for study device session is presented. Media selection involves three components: (1) determination of media requirements for each objective, (2) analysis of the requirements for individual objectives into optimum mixes of training media, and (3) selection of a final media mix based on cost and availability. This procedure accomplishes the first two components. The 11 steps in the procedure are described in detail. The result of this procedural approach is that all trainers, except the last of each type, will have enough objectives assigned to them to fill all available time. Following this process, it is necessary to develop a detailed set of functional specifications and detailed costing and support-requirements for each proposed trainer. This must be done with the manufacturer of the equipment.

Carpenter, P. An overview of MODIA: A method of designing instructional alternatives for Air Force training. Santa Monica: Rand Corporation, November 1972. (AD-760 046)

Rand Corporation is developing a model to augment the Air Force's Instructional Systems Development model. This model--referred to as MODIA, Method of Designing Instructional Alternatives--addresses administrative and training aspects of training program design. Media taxonomies and cost effectiveness of media categories are examined. MODIA is computerized and designed to aid the decision maker in exercising his responsibilities.

Department of the Air Force. Instructional system development (AF Manual 50-2). Washington, DC: Author, July 1975.

This technique is based on a matrix consisting of six types of learning objectives and ten types of instructional media. Each matrix cell receives a low, medium, or high classification that provides an indication of the usefulness of that medium for achieving the particular learning objective.

Department of the Navy. Military specification: Training requirements for aviation weapon systems, MIL-T-29053. Washington, DC: Author, October 1977.

This Navy specification contains a detailed media selection model presented in terms of relevant questions, alternative paths based on answers to the questions, and ultimately recommendations for appropriate media. Important variables affecting the media selection process include instructional display requirements, student response detection capabilities, feedback requirements, and student program interaction level. Student program interaction covers hands-on objectives, information storage and generation requirements, and program constraints such as cost and safety. The media alternatives to be considered must represent the range of candidate media falling within the constraints of program feasibility.

The representative media types considered in this model include mediated interactive lectures, workbooks, slide-tape presentations, random access slide presentations, video-tape presentations (animated videotape, level-three videotape, level-two videotape, level-one videotape, home-movie level videotape), computer-assisted instruction, and hands-on exercises. Instructional requirements for training devices are described in terms of functional purpose and required capability, known or estimated training equipment hardware and software functional capabilities, distinguishing capabilities from alternative instructional features, and criticality to training. This procedure appears to offer much promise.

Eckstrand, G. A. Current status of the technology of training (Tech. Rep. 64086). Wright-Patterson Air Force Base, OH: September 1964.

This report presents an overview of training technology. The processes of determining training requirements, developing training environments, and measuring training results are reviewed. Media decisions occur during the development of an appropriate training environment. The complexity of military jobs and requirements for training efficiency have led to the increased role of training devices in training systems development. However, engineering technology related to simulation has grown more rapidly than our ability to specify the characteristics that a particular simulator should have to most effectively accomplish specified training objectives. Therefore, physical fidelity is often emphasized at the expense of functional fidelity. Information exists on each type of media, however, procedures for selecting media to meet specific requirements is still in a preliminary stage of development.

Johnson, S. L., Buchenmaier, C. C., & Sugarman, R. C. Instructional system design for aircrew training. Proceedings of the Eighteenth Annual Meeting of the Human Factors Society, Huntsville, AL, October 1974.

This paper discusses the methodology and output of the instructional systems development (ISD) process for the crewmembers of the B-1. Selection of appropriate media for the academic portion of the training program has a large impact on the time-phasing of the instructional system. Advances in computer-assisted and managed

instruction for pilot training are relevant to media decisions. Relative advantages of individualized instruction and integrated crew training can be assessed. The hardware technology available for simulation in training is ahead of the behavioral technology availabe for making adequate media decisions.

Jorgensen, C. C. A methodology and analysis for cost-effective training in the AN/TSQ-73 missile minder. Fort Bliss, TX: U.S. Army Research Institute for the Behavioral and Social Sciences, September 1976.

Jorgensen proposes media selection by performing a cost and training effectiveness analysis (CTEA) within a cost and operational effectiveness analysis (COEA). Jorgensen formed a matrix with 55 generic media characteristics on one axis and 75 media types on the other axis. Next, judges assigned applicability ratings to each matrix cell based on the degree to which each type of media delivers each of the characteristics. Then, tasks to be trained were assigned to the various generic media characteristics appropriate to their use in training. Those media that contained the largest number of applicable characteristics for the tasks were then selected for a detailed cost analysis according to the computerized cost model.

Kinkade, R. G., & Wheaton, G. R. Training device design. In Van Cott and Kinkade (Eds.), Human Engineering Guide to Equipment Design. Washington, DC: U.S. Government Printing Office, 1972, 667-699.

The authors qualify levels of training into indoctrination, procedural, familiarization, skill, and transition. They associate different types of training devices with each level. Training devices are then divided into training aids (e.g., films, TV) and training equipment. The training equipment category includes part-task trainers, such as driver trainers, and whole task trainers, such as weapon system simulators. At higher level types of training, training equipment is generally recommended. Training aids appear to be recommended primarily for passive learning tasks.

Narva, M. A. Development of a systematic methodology for the application of judgmental data to the assessment of training device concepts. Paper presented at the U.S. Army Science Conference, West Point, June 1978.

The paper considers the time constraints resulting from concurrent development of prime and training systems. A method called TRAINVICE was developed to assist in the development of training concepts. Task commonality, physical characteristics, functional characteristics, skill and knowledge requirements, and task training-difficulty ratings are all derived as part of the training effectiveness analysis. These ratings integrate judgmental processes within a framework that can be used during the development of training devices.

Nawrocki, L. Paper presented at Computer Systems Tutorial at the 22nd Annual Meeting of the Human Factors Society, Detroit, October 1978.

The future of videodiscs as media for instructional delivery is discussed. Videodiscs can store much more information than magnetic discs. The outstanding capabilities of videodisc technology with educational implications are: (1) automatic frame stop, (2) dual audio track, (3) random access of visual scenes as opposed to serial access of other available media (e.g., videotape, film), and (4) fast forward or reverse search.

Clearly, the impact of videodisc will be substantial in the 5- to 10-year planning horizon. Any weapon system originating in the next few years should consider using this technological advancement.

Nunnelly, C. L., Klemmer, A. G., Corrigan, R. E., & Kaufman, R. A. The instructional system approach to maintenance technical training: Development and implimentation model. Human Factors, 1966, 8, 163-172.

This article presents an instructional system model for meeting the maintenance training requirements for weapon systems. The model proceeds in five phases: system analysis, equipment/hardware analysis, human component analysis, synthesis of hardware and software into precise training requirements, and method/media selection. Methods refer to the strategies for achieving desired terminal performance, while media are the tools by which the methods are implemented. The stages of this phase include task identification, response characterization, simulation criticality and learning difficulty, learning method, and instructional setting. The emphasis in this article is on organizing decisions, rather than replacing subjective inputs of analysts.

Parker, J. F., Jr., & Downs, J. E. Selection of training media (Tech. Rep. ADS TR 61-473). Wright-Patterson Air Force Base, OH: Aeronautical Systems Division, September 1961.

Parker and Downs discussed the translation of statements of desired personnel performances and capabilities and task analysis documents into training objectives. They identify three classes of simulation of the contextual environment. Extraneous contextual cues include general irrelevant environment cues accompanying task performance. Performance degraders are forces that cannot be overcome to any appreciable extent by practice and tend to lessen performance capabilities in a relatively constant manner. Performance disruptors are forces that are disruptive at first, but can be overcome through practice. Therefore, performance disruptors should be simulated, while there is little benefit to simulating performance degraders.

Rhode, W. E., Esseff, P. J., Pusin, C. J., Quirk, F. B., & Shulik, R. Analysis and approach to the development of an advanced multi-media instructional system. Vol. I (Tech. Rep. 69-30). Wright-Patterson Air Force Base, OH: Air Force Human Resources Laboratory, Air Force Systems Command, May 1970.

Westinghouse Learning Corporation conducted a study to review and assess current instructional media in terms of functional description, instructional flexibility, support requirements, and costs. A model of an individual instructional system is suggested. Requirements and features of automated management information and control subsystems are outlined, and major features for developing such a system are described. This study provides a needed data base for future planning. The instructional media were portable instructor aids, television, portable VTR systems, student response systems, dial access informaton retrieval systems, learning laboratories, programmed text, teaching machines, learner centered audiovisual devices, simulators, and advanced concepts. The report was designed for use with a broad range of training tasks, and not intended to be a media selection technique. However, an abundance of valuable data to support a training system developer in media related decisions is provided.

Siegel, A., & Federman, P. J. <u>Development of a method for deriving required training aids/devices and applications to the tactical coordinator position in ASW aircraft</u> (Tech. Rep. NAVTRADEVCEN 68-C-0212-1). Orlando: Naval Training Device Center, June 1970.

Two scales were developed to rate the amount and taxation level of intellectual activity required in performing a task. The intellectual operations are cognition, memory, divergent production, convergent production, and evaluation. These intellectual operations are based on Guilford's structure of intellect model. Values for the amount of intellectual activity and taxation level of intellectual activity are combined with predetermined values of the suitability for each instructional medium to exercise each of the intellectual operations. These values are obtained by averaging judgments of a group of subject matter experts. Resulting numerical values are used to determine if a training objective is sufficiently difficult or demanding to require media support. If the threshold value is attained or passed, these values are then used to establish a ranking of appropriate selected media. The media include programmed instruction, slides, gaming, dynamic trainers, television, and eleven additional methods.

Spangenberg, R. W., Riback, Y., & Moon, H. L. <u>The state of knowledge pertaining to cost-effective training methods and media</u> (HumRRO Tech. Rep. 73-13). Alexandria: Human Resources Research Corporation, 1973.

This report includes a reviw and analysis of relevant media-selection procedures for cost effective use of media in Army training programs. Existing training-methods and media-selection procedures and training cost analyses are not adequate. The inadequacies relate to two basic problems: procedures developed for civilian use do not apply to Army conditions and existing procedures are too general for specific application.

To create the external conditions required for learning, media must: present stimuli, direct student activities, provide models for terminal performance, provide prompts, guide thinking, induce transfer of knowledge, and provide feedback. Media-selection approaches must include exhaustive lists of alternative types, media definitions must be based on media attributes, and the definitions must be relatable to user identified media requirements. Defining media in terms of aggregate sets of capabilities appears to be a reasonable method for objective definition.

Sugarman, R. C., Buchenmaier, C. C., & Johnson, S. L. Systems approach to training (SAT) for the B-1 aircrew. <u>Proceedings of the Eighteenth Annual Meeting of the Human Factors Society</u>, Huntsville, AL, October 1974.

Development of a methods/media catalog to serve as an aid in the selection of presentation techniques is suggested. The data in the catalog would serve to analyze simulation technology. Factors of cost, availability, support personnel and material requirements, and facilities requirements would be specified. Behavioral technology advances in transfer of training and learning theory research can be introduced in terms of their implications for teaching methods and training equipment.

USAF 3306 Test and Evaluation Squadron. <u>Mission Handbook.</u> Edward Air Force Base, CA: Author, June 1977.

This handbook describes in detail the Air Force 3306 Test and Evaluation Squadron's approach to instructional systems development (ISD). The handbook presents an ISD model for new weapon systems. A section in the handbook addresses the selection of

training media. Subject matter experts (SMEs) review each behavioral requirement and determine the best media to satisfy it. A rationale checklist and training media analogram are used by the SME to reach media selection decisions more objectively. Instructional media are reviewed as supplemental (i.e., media are designed to accomplish a training objective that cannot be accomplished by an instructor alone). Not all training objectives require the use of media. A real need must be demonstrated before media are procured. The media analogram is a valuable aid in selecting a particular class of media.

Walker, R. W. An evaluation of training methods and their characteristics. Human Factors, 1965, 7, 347-354.

When technical training specialists and supervisors were asked to list the factors they used to select training techniques, 34 factors were identified. A group of training specialists was then asked to rate each of 16 training techniques on each of the selection factors. Based on these data, a matrix was produced that contained average values for each training technique by selection factor. Training program designers may use the matrix by specifying real-world conditions such as budgetary restrictions, personnel considerations, and equipment requirements. They use the matrix to select the training technique best suited to the given operational parameter set.

Wheaton, G. R., Fingerman, P. W., Rose, A. M., & Leonard, R. L., Jr. Evaluation of the effectiveness of training devices: Elaboration and application of the predictive model (Res. Memo. 76-16). Alexandria: U.S. Army Research Institute for the Behavioral and Social Sciences, 1976.

Planning, designing, and developing a training program incorporating required devices is difficult. One begins by stating training requirements, identifying what needs to be trained, and then specifying a general training system to meet these objectives. At this stage, the specification is functional, rather than hardware oriented. Converting the functional specification into hardware is done systematically. The TRAINVICE model presents an approach, based on a transfer of training model, to predict and evaluate the effectiveness of training devices. The model is presently not used in selecting media, but the learning theory approach may have application to media selections.

Training Program Assessment

Branch, K. V., Duffy, L. R., & Staley, J. D. Design of training systems, phase IV report (TAEG Tech. Rep. 37). Orlando: Training Analysis and Evaluation Group, October 1976. (AD-A046 700)

Branch, K. V., Staley, J. D., & Yanko, R. E. Design of training systems, users manual (TAEG Rep. 36). Orlando: Training Analysis and Evaluation Group, September 1976. (AD-A040 238)

Duffy, L. R. Design of training systems utility assessment (Tech. Rep. TAEG-33). Orlando: Training Analysis and Evaluation Group, May 1976. (AD-A026 289)

Duffy (1976); Branch, Duffy, and Staley (1976); and Branch, Staley, and Yanko (1976) all discussed the Design of Training systems (DOTS) project in which two computer based models were designed, developed, and validated. The first model--the system capabilities/requirements and resources (SCRR) model--incorporates operations research techniqes to optimize training student throughput and resource utilization, given an extensive data base describing resources available and the required student throughput. The training process flow (TPF) model has as its input, the output of the SCRR model and

predicts training system performance based on statistical analyses of historical data and computer simulation. The overall package was intended to permit rapid determination of the effects of potential training system alterations (e.g., resource availabilities and assumptions). Additionally, it was designed to be used in an interactive mode, if desired, to permit an iterative exploration of alternatives.

Goldstein, I. L. A systems approach to studying organizations: Selection, training, performance. Proceedings of the Human Factors Society 22nd Annual Meeting, Detroit, October 1978, 88-90.

In assessing effectiveness of training programs, the usual approach is to measure performance before and after instruction and make comparisons to appropriate controls. While this approach provides valuable information, the author feels it ignores many aspects of the training process. Data obtained during training may be used to predict on-the-job performance. The potential for enhanced predictability may be cost effective relative to the operational system in some circumstances. Where cost of training is an important factor, one can use other measures to predict training performance and, then, use actual training performance to predict job performance. Another area in which training programs can influence job performance is the training expectations and job expectations that the trainees bring with them. Realistic job previews during recruitment have been found to reduce the number of early turnovers within an organization. Since the training program is the point of entry into an organization, realistic, and accurate information during training might smooth the transition from training to job, which might improve the chances of job success.

Grace, G. L. Human effectiveness and evaluation. Proceedings of the Human Factor Society 18th Annual Meeting, Huntsville, AL, October 1974, 57-60.

Recent social and economic developments in this country have increased the importance of the human factors of effectiveness, that is the motivation and utilization of human resources. The process of evaluation is one method of determining improvement in human effectiveness. This paper describes the evaluation of two programs (one of which is the Navy Career Counseling Program) designed to increase effectiveness. As a result of the evaluation, many modifications have been implemented in this program.

Hall, E. R., Lam, K., & Bellamy, S. G. Training effectiveness assessment: Volume I, current military training evaluation programs (TAEG Rep. No. 39). Orlando: Training Analysis and Evaluation Group, December 1976.

Philosophy, methods of documentation, and current practices in training effectiveness assessment are reviewed for Air Force, Navy, Army, and Marine Corps programs. Each program is evaluated in terms of apparent strengths and weaknesses. Considerable variability exists in the way each of the services defines and implements it training evaluation activities. Some of the variability is due to differences in mission. For example, the Army concept is keyed to contributions to combat readiness, as opposed to the effectiveness of particular courses.

Hall, E. R., Rankin, W. C., & Aagard, J. A. Training effectiveness assessment: Volume II, problems, concepts, and evaluation alternatives (TAEG Rep. No. 39). Orlando: Training Analysis and Evaluation Group, December 1976.

Specific problems affecting training evaluation programs are identified. General procedures are presented for assessing the effectiveness of training courses for gathering required evaluation data. One recommendation is for the establishment of a training

effectiveness assessment center to serve as a centralized agency assisting in the planning and conduct of training evaluations.

A number of factors can limit the value of training evaluation programs. These are intensified by some negative attitudes toward evaluation in general, and these attitudes can be made worse as a result of administrative problems and lack of command emphasis. Greater emphasis is also needed to train military personnel to conduct detailed training analyses. Unless these factors are systematically addressed, training evaluation programs will continue to suffer.

Holshouser, E. L. Human factors engineering test and evaluation technology. Proceedings of the Human Factor Society 18th Annual Meeting, Huntsville, AL, October 1974, 343-349.

In implementing Department of Defense Directive 5000.1 (outlining policy for major defense system acquisition), the Naval Air System Command has proposed human factor testing and evaluation (T&E) of any system requiring the approval and processing of the Defense Systems Acquisitions Review Council (DSARC). The framework of this new policy is a series of decision points addressing program need, cost, and direction. At each decision point, critical questions and issues are resolved through T&E before moving to the next decision point. The ultimate goal is to ascertain operational suitability of new Navy systems through systematic methodologies of T&E technology. The proposed system provides a clearing house for documentation storage and retrieval of human factors T&E data for use by the developers of future systems.

Jensen, H. E., & Valentine, L. D., Jr. Validation of ASVAB-2 against civilian vocational/technical high school criteria (AFHRL TR-76-16). Lackland Air Force Base, TX: Personnel Research Division, Air Force Human Resources Laboratory, March 1976. (AD-A023 118)

The recently developed Armed Services Vocational Aptitude Battery (ASVAB-2) was taken by a high school population and the results compared against later performance by the population in civilian vocational technical courses. The data indicate that ASVAB's utility is equal to or somewhat superior to commercial aptitude batteries. Statistical data are given for 41 vocational-technical fields.

Leuba, H. R. A systems approach comes to personnel management. Proceedings of the Human Factors Society 19th Annual Meeting, Dallas, October 1975, 467-472.

The systems approach to problem solving was applied to the problem of personnel performance evaluation. Data were collected and analyzed to define the purpose, enumerate the characteristics, and discuss the mechanisms used to implement a system of personnel performance evaluation. A system must have a well-defined purpose and be based on the list of 80 characteristics outlined. The mechanisms to be used depend on the needs of the using organization. Any operating system should be flexible enough to allow employees and managers to be involved at the level of participation in the system meeting their needs at the time. Additional details are available to those who want to try this solution.

Lindahl, W. E., & May, D. E. Programming Navy specialized training. Report prepared for the Deputy Assistant Secretary of the Navy (Manpower), August 1978.

Results of research and analysis of the specialized training programming process were identified. In this report, procedures specified in the training portion of the Navy's

Lockway, M. R., & Yasutake, J. Y. The evolution of the Air Force advanced instructional system. The Second Symposium on Cost Effective Learning Through the Application of Computer Technology, Washington, DC, February 1973, 112-133.

This paper presents an overview of the Air Force's Advanced Instructional System (AIS), which is a proposed computer-based multimedia system for the administration and management of individualized technical training on a large scale. The AIS system is broken down into seven subsystems: (1) instructional materials, (2) instructional strategies, (3) media, (4) computer software, (5) computer hardware, (6) personnel and training, and (7) related subsystems.

The authors contend that the uniqueness of the AIS is expressed in several ways: (1) It is the first attempt to integrate all of the technology required for cost effective implementation of large-scale individualized instruction. (2) It provides the capability of using several methods and media rather than just programmed instruction or CAI. (3) It has capacity for incorporating instructional and management innovations as they become available. (4) It has inherent capacity for continuously evaluating and upgrading its own cost effectiveness. (5) AIS is designed as a total system to perform all of the instructional system design, administration, and management required to conduct a large-scale training enterprise.

Sugarman, R. A second chance for computer-aided instruction. IEEE Spectrum, August 1978.

In this article, the shortcomings of CAI in the last decade are attributed to the lack of proper courseware development, and not to the inadequacy of the media itself. New course-generation languages, such as Tutor, provide the opportunity for significant improvements in the near future. Sugarman also suggests that the economics of going from large time-sharing computer systems to support CAI to low-cost stand-alone systems may encourage more institutions to consider CAI as an instructional medium. However, the large amount of preparation time per hour of lecture (estimated at 50 hours per hour of lesson) still appears to be a major stumbling block for full-scale acceptance of CAI by the education and training community.

Sugarman, R. What's new teacher? Ask the computer. IEEE Spectrum, September 1978.

The following applications of CAI are proposed: (1) It can permit the learner to see what he is doing and what progress has been made. (2) It can function as an "articulate expert," by using the large information storage capabilities. (3) It can be used as a home library, by employing videodisc technology. (4) It can be used as a low cost simulator to avoid the costs of expensive simulator hardware.

Valverde, H., & Morgan, R. L. Influence on student achievement of redundancy in self-instructional materials (Tech. Rep. AMRL-TR-68-75). Wright-Patterson Air Force Base, OH: Aerospace Medical Research Laboratory, December 1968.

This study investigates the effect of redundancy on learning from self-instructional material. Redundancy is defined as the use of more words, instructional materials, or support materials than are necessary to teach desired behaviors. The results indicated that eliminating the usual redundancy in a linear program significantly increased student achievement.

McCann, P. H., Lahey, G. F., & Hurlock, R. E. A comparison of student option versus program controlled CAI training (Tech. Rep. SRR 73-17) San Diego: Naval Personnel and Training Research Laboratory, April 1973.

Students were allowed to select their training from an index of descriptive lesson objectives or they were pretested just before each lesson objective and, then, branched to the training sequence appropriate to their level. A pretraining narrative presentation was given to half the students. No significant differences were found in test performance or training time measure in any of the four experimental conditions. Students who selected their own training had more favorable attitudes toward CAI. A pretraining narrative was felt to be a valuable aid.

Pollack, H. Time and cost effective techniques in supportive computerized training systems. Proceedings of the 6th NTEC/Industry Conference, Orlando, 1973.

The author concludes that computer usage will remain in a supportive role in the educational process until its inability to make adjustments in lesson presentation through student feedback is accomplished. Steep hardware and telephone transmission costs are a large impediment toward a more pervasive usage of CAI throughout the nation. To maximize its cost effectiveness, the computer should be used only for those activities in which it clearly surpasses all other media.

Pollack suggests that: (1) Text storage and graphics should be left to workbooks and handouts used to minimize storage and equipment expense. (2) Randomization of data, calculations, and management of student records are fortes of the computer and will save student and instructor time. (3) Socratic method of lesson development should be left up to the human teacher.

Rigney, J. W. A discussion of behavioral technology laboratories CAI projects in relation to a CAI test-bed concept (Tech. Rep. 71). Los Angeles: University of California, Department of Psychology, July 1973.

The intent of the report is to present the major elements of computer-assisted instruction (CAI), relate them to laboratory research findings, and describe projects underway at Behavioral Technology Laboratories. CAI elements are discussed with reference to a block diagram depicting 13 elements, their grouping, and interactions. In a sense, this CAI model represents a generalized instructional system. Major focus of the discussion concerns the elements that are collectively called internal processing. This block represents the students' internal subjective processing of the instructional materials and sequences. Although a good deal of laboratory research has been directed at this area, these findings are not directly translatable to applied instruction. Research in such areas as mental imagery, human information processing attention, and organization in memory can be useful to CAI design, if suitable transformations to applied problems can be specified. According to the author, the chief means for currently influencing the students, learning is through the sequencing of instruction. Use of the findings, models, and theories from the laboratory can potentially expand the control of learning.

Rigney, J. W., & Towne, D. M. Computer-aided performance training for diagnostic and procedural tasks. The Second Symposium on Cost Effective Learning Through the Application of Computer Technology, Washington, DC, February 1973, 179-207.

The authors have given an example of the use of CAI in diagnostic and procedural tasks through their training computer program TASKTEACH. The specific examples of software and hardware used in conjunction with TASKTEACH are explicated along with a lengthy list of computer subroutines.

(equipment) are higher. Operating at full capacity, the PLATO system is cost effective. Potential applications need to be explored.

Lahey, G. F., Hurlock, R. E., & McCann, P. H. Post lesson remediation and student control of branch in computer based training (Tech. Rep. SRR 73-19). San Diego: Naval Personnel and Training Research Laboratory, April 1973.

Training time and final examination performance are as good when students select their own training material as when selection of materials is controlled by the program. Also, students in a no-remediation control group do as well as students receiving remediation after failing to pass lesson tests. Students prefer student controlled training.

Landa, S. CATTS: Computer-aided training in troubleshooting (Tech. Rep. R-518-PR). Santa Monica: Rand Corporation, May 1972.

This report examines computer-aided instruction (CAI) as an efficient and effective teaching medium. CAI offers the potential to decrease number of instructors, provide individualized instruction, and reduce long term equipment costs. Yet, most CAI systems have some limitations such as difficulty in using the graphical capabilities of CRT through course author languages. The author of this report describes on-going programs at Rand that permit direct and easy creation of graphic displays on a CRT. The Programmer-Oriented Graphics Operation (POGO) was used to train airmen in malfunction diagnoses. The initial tryout of the system proved quite successful. The problem structure of the prototype course provided a convenient framework for classroom presentation. The high cost of hardware necessary to support a graphics system is largely offset by resulting economies in instruction and teaching efficiency.

Mathis, A., Smith, T., & Hansen, D. College students' attitudes toward computer-assisted instruction (Unpublished manuscript). Tallahassee: Florida State University, 1969.

This study attempted to determine what aspects of the learning experience might influence student attitudes toward computer-assisted instruction (CAI). Sixty-four randomly selected students were given CAI or reading materials on general psychology. Half saw familiar material, half saw unfamiliar material. Half were pretested for prior attitudes toward CAI. The analysis showed that pretesting had no effect. Student attitudes toward CAI were influenced more by actually experiencing CAI than by readings. A significant factor in determining the positiveness of a student's reaction to CAI was the course taken. The magnitude of the change in attitude was dependent upon the kind of experience the student had. Those students who were given familiar, immediately relevant material showed most increase in positiveness. Those students who made more errors were less favorable to CAI. These results indicate that it may be possible to convert students to CAI as a method of instruction if they are given relevant programs that do not allow them to make too many errors.

Mayo, G. D. Computer managed instruction. The Second Symposium on Cost Effective Learning Through the Application of Computer Technology, Washington, DC, February 1973, 134-140.

Computer-managed instruction (CMI) is defined and a few examples where training efficiency was dramatically increased throught the use of CMI are given. A scientific evaluation of three instructional modes is proposed: (1) a group instructed by CMI; (2) a group instructed by individually-paced instruction with minimal computer support; and (3) a group instructed by conventional classroom procedures. This study should delineate more clearly the relative advantages of these modes of instruction and the parameters of training efficiency and cost.

techniques. The authors of that project were Ford, Slough, and Hurlock (1972) under the auspices of the naval Basic Electricity/Electronics School (BE/E). Five CAI modules were developed and implemented at the (BE/E) school during this project. Comparison of the comparative results between the CAI modules and with the traditional instruction yielded these favorable conclusions: (1) CAI provided very effective training. (2) CAI students scored consistently higher than students given conventional classroom training. (3) CAI training was very efficient since 45-percent less training time was required. (4) Student reactions to CAI programs were predominantly favorable with a few exceptions. (5) Students preferred to take the bulk of their training by CAI.

Hansen, D. N., Kribs, D., Johnson, B., & Dick, W. Office of Naval Research sponsored project on computers and instruction. Tallahassee: Computer-Assisted Instruction Center, September 1973.

Florida State University conducted a five-year study on learning strategies, training strategies, validation strategies, and computer system strategies. Learning strategy research focused on the interaction of adaptive instructional design with task and learner characteristics. Computer-managed instruction was the central area in training strategy. Sequential and tailored testing research was also covered. The results were analyzed in relation to ongoing Navy training methods, existing constraints, and future requirements. Computer system strategies included interactive systems, data analysis development, and management strategies.

Hurlock, R. E. Applications of pretest branching designs to CAI basic electronics training (Tech. Rep. SRR 73-8). San Diego: Naval Personnel and Training Research Laboratory, September 1972.

Pretest branching strategies intended to adapt instruction to individual training needs were incorporated into a CAI system. Compared to fixed sequence lessons, pretest lessons allowed a much greater range in training time.

Hurlock, J. A., & Hurlock, R. E. Comparision of paired students and individual students trained by CAI (Tech. Rep. SRR 73-21). San Diego: Naval Personnel and Training Research Laboratory, June 1973.

An experiment was done to determine if existing CAI programs could train paired students, as well as individuals. The results showed that paired student training was as effective as individual training and reduced the cost per terminal hour. CAI course materials was basically linear and students were paired on the basis of learning rate and aptitude.

Hurlock, R. E., & Slough, D. A. Experimental evaluation of PLATO IV technology: Final report (NPRDC Tech. Rep. 76TQ-44). San Diego: Navy Personnel Research and Development Center, August 1976.

The results of eight studies designed to evaluate the PLATO IV system of computer-based instruction for various content areas are summarized. Techniques investigated included: use of still, animated, and interactive graphics; simulation; drill and practice; feedback in the context of games; guidance of offline instruction; learner control of instruction; and use of preprogrammed instructional strategies. Measures of cost and training effectiveness were taken for the development and delivery of instruction. The system was found to be effective in training a variety of cognitive and procedural skills. The interactive graphic display and touch panel is an innovative and cost effective approach to simulation. Course development costs are reasonably low, but delivery costs

Key features of the CAI course were: (1) self paced, (2) hands-on practical exercises conducted in the student carrels, and (3) additional hands-on practical exercises using larger equipment conducted away from the carrels.

Summative evaluation of the implication of the CAI course yielded the following results: (1) higher achievement for CAI group; (2) retention and transfer enhanced by CAI; (3) failure rate reduced by 21 percent for CAI group; (4) training time reduced by 35 percent for CAI group; and (5) highly favorable student attitude toward CAI.

The interest in CAI engendered by these results prompted the Continental Army Command (CONARC) to establish a task study group. The major findings of the study group were: (1) Most technical courses--especially those with one-to-one student-to-equipment ratios--are suitable for presentation by CAI. (2) Nontechnical courses are equally--if not more--suitable for presentation by CAI. (3) CAI is cost effective in comparison to conventional instruction when the student load is high enough to offset the added costs of buying or leasing computer hardware and software. (4) The most plausible hardware configuration for future CAI efforts in the Army is one that makes use of the multiprocessor, minicomputer concept. (5) The intangible benefits from the application of CAI are as important as those that can be measured empirically.

Dick, R. A., Royal, J. W., Simpson, H. K., & Mackie, R. R. Personnel technology: Using an inexpensive computer-based system to teach performance-oriented skill (Tech. Rep. 1728-1). Arlington: Personnel and Training Research Programs, June 1974.

Computer-based and programmed textbook-based curricula for training students were compared. The curricula were identical except that students in the computer-based course received simulation training and students in the textbook-based course used diagrams and written explanations. Although the computer-based curriculum seemed to be more stimulating, no advantage in actual learning was observed for the computer trained group.

Fletcher, J. D. Computer application in education and training status and trends (NPRDC Tech. Rep. 75-32). San Diego: Navy Personnel Research and Development Center, April 1975.

Major developments in the military and civilian sectors are described in computer-based training, with emphasis on computers for teaching and instruction and on new developments with implication for future Navy training. The operational implementation of computer-based training is proceeding more rapidly than the assessments of their economic, technological, and pedagogical impact. Much attention is presently directed at computer-managed instruction, use of models, student control, authoring and author languages, and cost of material preparation costs. Simultaneously, the Navy has defined its training system characteristics. Systems must lead to decreased costs, be portable, be relatively instructor free, and be distributed across Navy locations. Therefore, instruction must be flexible and modular. Advances in computer technology are making this possible. If technology advances are coupled with systematic long term planning, computer based training offers major economies and efficiencies in the future.

Ford, J. D., Jr. CAI for Navy technical training. The Second Symposium on Cost Effective Learning Through the Application of Computer Technology, Washington, DC: February 1973, 230-242.

Much of the information presented in this paper came from a project to develop CAI techniques and methods and to test the CAI training modules derived from those

performance. The study focused on the selection of individual difference measures, selection of training topics, development of experimental courses, and development of criterion measures. The most compelling effect was the interactive relationship between learner anxiety and the method of instruction. However, most relationships among major variables did not show strong effects. The authors believe that noncognitive learner characteristics have not received adequate evaluation.

Taylor, J. E., Montague, E. K., & Hanke, R. The interrelationships of ability level, instruction system, and skill acquisition (Tech. Rep. 29-70). Alexandria: Human Resources Research Organization, September 1970.

The Army's training population is large and heterogeneous. This project assessed the impact of these extreme aptitude differences upon learning performance in Army noncombat and combat skills, and undertook the development of instructional strategies to optimize training efficiency for men of differing aptitude levels. High aptitude learners seem to learn most efficiently when left alone with the instructional objective and the necessary materials. The middle aptitude trainees appear to learn most efficiently if they have a person of authority of whom they can ask questions. Low aptitude trainees require complete structuring of course material and an instructor to give prompting and feedback. The high variability in performance among low aptitude trainees was examined.

Valverde, H. H. Effect of confirmation peeking and response mode on programmed instruction (Tech. Rep. 67-225). Wright-Patterson Air Force Base, OH: Aerospace Medical Research Laboratory, April 1969.

An experiment was done to test the effect on learning efficiency of different response modes in programmed texts. Two response modes were compared, a covert mode which encouraged peeking, and an overt mode which did not permit peeking. Programmed texts on radar orientation were administered to 78 Air Force pilot trainees. The rate at which the subjects completed the program was the measure of efficiency. No statistical difference in efficiency was found between the overt and the covert group.

3. Computer Assisted/Managed Instruction.

Charp, S. Use of the computer for individualization of instruction. The Second Symposium on Cost Effective Learning Through the Application of Computer Technology, Washington, DC: February 1973, 307-322.

The results of introducing computer assisted and managed instruction (CAI and CMI) into the Philadelphia School System as instructional alternatives in general math, algebra, reading, biology, and electronics are described. The increased effectiveness and time savings of CAI and CMI seem to point toward their expanded role in the educational system at large. However, high courseware development costs may markedly constrain that growth.

Cieri, V. P. Development of a computerized training system for future army training. The Second Symposium on Cost Effective Learning Through the Applicaton of Computer Technology, Washington, DC: February 1973, 212-229.

The author summarizes the development and evaluation of a tutorial mode computer-assisted instruction (CAI) project developed for use at the U.S. Army Signal Center and School.

instructional strategies. Recent observers have suggested that a more eclectic approach to instructional design be followed. Such an approach requires that several small-scale theories or models be developed to specify the students' internal processing modes and, thus, serve as a basis for instruction. After this brief sketch of the role of theory, Powers examines the interaction of learner traits with instructional strategies. Research on adaptive training suggests two important conclusions: (1) Learner traits may interact with may variables in addition to instructional technique. (2) Many of the traits upon which instruction is selected (e.g., general intelligence) may in fact be insensitive indicators of adaptive instruction. More pragmatic approaches to adaptive instruction are required to take into account the several important variables that might impact upon type of instruction. Early application of adaptive training techniques did little more than pace the rate of instruction for the individual. Such factors as content and sequence of instruction may provide better modulation of learning. Furthermore, adaptation of instruction based on within-task performance offers improved impact of the adapted instruction.

Rankin W. C., & Hall, E. R. Demonstration of a methodology for classifying naval training courses (TAEG Rep. No. 51). Orlando: Training Analysis and Evaluation Group, November 1977.

This report documents the development of a methodology for classifying naval training courses. Data were gathered from over 400 Navy enlisted technical training courses and analyzed by a computer-based clustering algorithm into homogeneous subgroupings based on similiarities among courses. The ultimate goal was to provide training management with an information structure to support decisions about: (1) instructor requirements, (2) training media and equipment, (3) training facilities, (4) kinds of skills trained, and (5) strategies for training and evaluation. This approach is based on a numerical taxonomy that permits natural categories to emerge, rather than preconceived notions of what constitutes the categories. Hypothetical data are used only to illustrate how the clustering program works.

Tallmadge, G. K., Shearer, J. W., & Greenberg, A. M. Study of training equipment and individual differences: The effect of subject matter variables (Tech. Rep. NAVTRADEVCEN 67-C-0114-1). Orlando: Naval Training Device Center, May 1968.

This report was aimed at defining instructional methods that differ in design and use as functions of learner characteristics. Two subject matter areas were selected: logico-mathematical procedures and visual-form discrimination. Two separate courses were developed for each subject matter area. One approach was inductive and the other was deductive. Furthermore, each student was tested on 28 measures of aptitude, interest, and personality variables. The results of the study support the existence of individualized learning styles and the use of multitrack instruction as a cost effective means of improved learning. The report also includes a summary of style literature. The survey considered both cognitive and noncognitive characteristics of learners. The important role of subject matter content is often overlooked in analyses of interactions between learning styles and instructional methods.

Tallmadge, G. K., & Shearer, J. W. Study of training equipment and individual differences: Research on interactive relationships among learner characteristics, types of learning, instructional methods, and subject matter variables. Orlando: Naval Training Device Center, June 1970.

A model was developed for simultaneously examining the effects of learner characteristics, types of learning, instructional methods, and subject matter variables on student

forms of adaptive systems: one in which the performance measurement and the adaptive variable change simultaneously, and another in which the rate of change of the adapative variable changes without a progressive change in the performance measurement during adaptation. In implementing any adaptive training system, the three essential elements in the adaptive trainer must be considered, and a series of decisions must be made with respect to each. When these choices are made skillfully and tested in the process, the training system can be much more effective as a result of having been made adaptive.

Koran, M. L. Individual differences in information processing: Comments on the paper by E. Hunt. In R. C. Anderson, R. J. Spiro, & W. E. Montague (Eds.), Schooling and the Acquisition of Knowledge: Conference proceedings (NPRDC Tech. Rep. 78-6). San Diego: Navy Personnel Research and Development Center, December 1977.

Research findings in the basic psychology of individual differences and in the area of learning have never been systematically combined although the results of such a combination might be used to adapt instruction to individual students. Attempts to individualize instruction have been based on hypothesized interactions between aptitude and treatment variables. Perhaps, initial research has been inconclusive, because the cognitive processes of aptitude and kinds of treatment were not considered. Current aptitude test items are chosen for their power to predict performance in our standardized educational programs and not for their relationships to potential intellectual processes. Measures need to be designed to tap different ways of learning. A closer analysis of cognitive processes may produce more effective mechanisms for instructional research into aptitude-treatment interactions.

Landa, L. N. Algorithmization in learning and instruction. Englewood Cliffs, NJ: Educational Technology Publications, 1974.

An algorithm is a method for carrying out the elementary operations necessary to solve a problem. The basic subject matter of this book is the application of algorithmic methods to education and psychology. The characteristics of algorithmic methods are contrasted with nonalgorithmic methods of problem solving. Theoretical problems in teaching algorithms are discussed. The logical and psychological problems in constructing algorithms of identification are considered, and mathematical methods in the analysis and evaluation of algorithms are presented. Research findings are discussed.

Modrick, J. A., Levit, R. A., Alden, D. G., & Henke, A. J. Review of approaches to cognitive style and implications for human information processing in command and decision situations. Proceedings of the Human Factors Society 19th Annual Meeting, Dallas, October 1975, 333-335.

This paper defines cognitive style as an individual's preferred and consistent way of organizing information and translating the processed information into overt action. There are a limited number of different cognitive styles, each with an associated strategy for problem solving. Representative concepts are summarized. The usefulness of the concept of cognitive style is discussed.

Powers, T. E. Instructional strategies and individual differences: A selective review and summary of literature. Princeton, NJ: Educational Testing Service, September 1976. (AD-A040 961)

The author begins with a review of the major theories that impact upon instructional design. Recent theoretical review has suggested that traditional theories of learning (e.g., Thorndike & Skinner) do not provide accurate guidance for development of

Fox, W. L., & Taylor, J. E. Adaptation of training to individual differences. Alexandria: Human Resources Research Organization, September 1967.

The U.S. Army has to train men of different aptitude levels in a wide variety of jobs. The objective of the research is to develop procedures for achieving effective training at all aptitude levels for men in high-density military jobs. The 15 tasks chosen for investigation had (1) elements in common with the skills and knowledge required in the majority of military jobs and (2) required skill levels that could be classified from simple to complex. Subjects were tested from a high aptitude group, a middle aptitude group, and a low aptitude group, as determined by AFQT scores. Training procedures were tailored to give the lower aptitude trainee every advantage. The results indicate that learning performance is directly, and highly, related to aptitude level across tasks and complexity levels. Performance was found to be related to training methods for both high and low level groups. Performance of individuals was found to be highly consistent across tasks. The low aptitude trainee can learn to perform a variety of tasks if the training methods have been carefully selected and organized to ensure his assimilation of the instruction.

Gopher, D. Williges, B. H., Williges, R. C., & Damos, D. L. Manipulating the number and type of adaptive variables in training (Tech. Rep. ARL-74-12). Urbana-Champaign, IL: Avionics Research Laboratory, October 1974.

Interest in automatically adaptive techniques is increasing, because such techniques might provide an optimum learning model to teach psychomotor skills. This study was designed to investigate the implications of adapting stimulus and response variables, the effect of varying the number of variables, and the usefulness of adaptive techniques in training for transfer to changing task conditions. Data were collected and analyzed for each adaptive variable. Results are discussed in terms of stimulus and response similiarity, the optimum number of adaptive variables, and the appropriateness of a changing task to evaluate adaptive training.

Hogan, J. C. Trainability of abilities: A review of nonspecific transfer issues relevant to ability training (Tech. Rep. ARRO 3010-TRI). Washington, DC: Advanced Research Resources Organization, January 1978.

A literature review was conducted to investigate the possibility of improving general abilities by training related, but not identical tasks. Areas reviewed include early memory training research, verbal and motor studies of warmup and learning to learn, effects of practice variability and learning without a prototype, and applied and educational training. Some indirect support for the feasibility of nonspecific transfer can be drawn from several areas of research, including simulator training and educational training. Further empirical testing is necessary. The implications of nonspecific transfer and ability training are discussed. These implications include the possibility of raising the ability levels of individuals whose work requires specific abilities and increasing the flexibility of personnel assignment in jobs through training.

Kelley, C. R. What is adaptive training? Paper presented at the meeting of the New England Psychological Association, November 1968.

Adaptive training is training in which the problem--the stimulus or the task--is varied as a function of how well the trainee performs. Performance must be continuously or repetitively measured in some way and, then, used to make appropriate changes in the stimulus, problem, or task. An adaptive trainer has three essential elements: the adaptive variables, the performance measurement, and the adaptive logic. There are two

Hammell, T., & Mara, T. D. Application of decision making and team training research to operational training: A translative technique (Tech. Rep. NAVTRADEVCEN 68-C-0242). Groton, CT: Naval Training Device Center, April 1970.

The present study developed and applied a technique for translating laboratory research findings in decision making into forms of use in training systems. The technique involved a decision skills taxonomy and a behavioral deficiency taxonomy. Research findings which were categorized using the two taxonomies, were useful in translated form for predicting the behavioral deficiencies that might be associated with operational decision tasks. The applicability of the translated research findings to training and real world systems was evaluated by analyzing submarine attack simulator (21A37/4) and actual at-sea performance data. A method was devised for applying for the translated research findings to decision making training.

Kribs, H. D., Thurmond, P., & Mark, L. Computerized collective training for teams (Tech. Rep. TR-77-A4). Alexandria: U.S. Army Research Institute for the Behavioral and Social Sciences, February 1977.

This report provides an initial framework for the development of instructional strategies for computer-assisted team training. This framework is based on a state-of-the-art assessment of instructional strategies and theories. Two conclusions are drawn: (1) At present there is no framework for a set of general purpose instructional strategies and (2) an instructional system development approach must be developed for team training. The initial framework developed, which requires much refinement and verification, is based on discussion and analysis of three factors underlying an instructional system: the characteristics of a team and of team tasks, the characteristics of the learner and of learner strategies, and the capabilities of computer-assisted instruction.

2. Adaptive/Individualized Training.

Charles, J. P., & Johnson, R. M. Adaptive training demonstrations--lessons learned. Proceedings of the Sixth Naval Training Equipment Center and Industry Conference. Orlando, November 1973, 449-459.

The technical feasibility of using automated adaptive training techniques in conjunction with instrument flight maneuver training is examined. Eight conclusions were derived from the results of the study. (1) Student performance must be quantified and summarized for automated adaptive instruction to be applied. (2) Although ultimate performance measures may not be available, existing measures are sufficient for successful application of adaptive principles. (3) Normalizing and averaging performance data provide adequate resolution for training control. (4) Introduction of artificial adaptive variables is probably not necessary, as sufficient analysis seems to reveal appropriate variables in all flight missions. (5) Adaptive training allows students to progress at their own speeds. (6) Adaptive training can enhance student motivation. (7) computer-controlled speech can successfully provide feedback to students. (8) Simple, adaptive algorithms can be applied successfully to modulate trial-by-trial performance. The benefits realized by the use of adaptive training techniques are: realizing training economies, increasing student motivation, expanding the training scope, obtaining objective performance data, and relieving instructors of some burdens thereby allowing more meaningful interactions with students.

team, a ship control team, and a flight deck team. From this descriptive work certain unexpected problems were found: (1) The boundaries of team membership were never as clearly defined as anticipated. (2) Teams undergo marked changes in composition and activity when the problems they face change. Various measures and different strategies were used to summarize the network of interactions between team members. The finding that team performance is almost entirely a chain of individual performance has implications for training.

This paper also examines the specific difficulties of team training, including the relative absence of satisfactory proficiency measures and the need for a team to be able to correct its own errors.

Finally, a literature review was conducted to find relevant information on group behavior and training problems. The areas covered include the dimensions of groups; the relation of attitudes, perception, and motivation to group performance; the use of special techniques for the improvement of group performance, communication networks; and the relation of individual proficiency to group performance.

Hall, E. R., & Rizzo, W. A. An assessment of U.S. Navy tactical team training (TAEG Rep. 18). Orlando: Training Analysis and Evaluation Group, March 1975. (AD-A011 452)

The report was prepared to provide information on current team training practices, problems, and research to be used for planning improved team training practices. Several team training sites including surface, subsurface, and air operations were visited and the relevant technical literature was reviewed to provide the basis for recommendation of solutions to current problems. The first problem encountered in examining team training was determination of a definition of "team." The following characteristics of a team were synthesized from the literature review: goal-or mission-oriented, formal structure, assigned roles, and interaction among members. Another term relevant to team training and requiring definition is tactical decision making. Again, the authors synthesized the following characteristics: situation diagnosis, hostile environment, selection of optimum alternatives, and some degree of uncertainty.

An important consideration in team training is the extent to which team performance is more than just a sum of individual performances. It is a widespread belief that this is so, but the relative contribution of individual performances is not well defined. Although many feel that team coordination should be trained, the meaning of the term is unclear. Thus, meaningful training objectives and methods for this aspect of team performance are difficult to achieve.

The Navy has two types of team training programs: training individuals to function as team members and training the intact team. The relative benefits or disadvantages of these two approaches have not been fully delineated. Examination of current naval team training practices revealed the current instructional technology is not applied. Specifically, clear objective training objectives are not specified in most cases, and teams are not provided with sufficient performance feedback. The authors recommend that in the future more emphasis should be placed on individual training at both the initial and refresher levels.

Semple, C. A. Guidelines for implementing training effectiveness evaluations (NTEC Tech. Rep. NAVTRAEQUIPCEN 72-C-0209-3). Orlando: Naval Training Equipment Center, April 1974.

This report describes problems encountered in field studies of training effectiveness. Procedures are presented for planning, implementing, and documenting training effectiveness evaluations. Such evaluations should provide quantitative and qualitative analyses of the effects of training methods upon student performance, cost of achieving benefits in student performance, and impacts upon other training resources. Basic assumptions include: existing training objectives are complete and objective changes to the training situation are relatively permanent, and baseline data exist on student performance levels. Training effectiveness evaluations can range from qualitative to carefully designed transfer of training studies.

Sheldon, M. S. Evaluation of training in a simulated environment. In J. E. Uhlaner (Ed.), Psychological Research in National Defense Today (Tech. Rep. S-1). Washington, DC: U.S. Army Behavioral Science Research Laboratory, June 1967.

This paper discusses the development of measurable criterion variables to assess empirical crew performance and considers some of the situational variables that must be part of the simulated exercise to extract meaningful measures.

Instructional Delivery Systems

1. Team Training.

Biel, W. C. Planning for team training in the system. In J. E. Uhlaner (Ed.), Psychological Research in National Defense Today (Tech. Rep. S-1). Washington, DC: U.S. Army Behavioral Science Research Laboratory, June 1976.

This paper describes the various general phases in the development process of an operational system and emphasizes the best time for considering team training requirements. The phases include concept phase, project definition phase, acquisition phase, and operational phase. Training requirements must be specified in the early concept phase.

Dieterly, D. L. Team performance: A model for research. Proceedings of the Human Factors Society 22nd Annual Meeting, Detroit, October 1978, 486-492.

The author briefly characterizes results of a literature review on team performance as emphasizing interpersonal interaction variables. Although these variables are seen as important, the author suggests that analysis of task interactions is a more critical research approach. To stimulate this research, a team performance model is proposed. This model contains five variables: individual capabilities, task function design, communication, control, and decision. The variable of task function design is emphasized to indicate one of several bases for research on team performance. This variable refers to the tasks and task interactions that may be defined in a team situation. The author maintains that this is a relatively neglected approach to the analysis of team performance and provides a good starting point for research programs on team performance.

Glanzer, M. Experimental study of team training and team functioning. In R. Glaser (Ed.), Training Research and Education. New York: Wiley, 1965.

Data were gathered and analyzed to experimentally describe a team. Four types of Navy teams were extensively observed: a gunnery team, a combat information center

Montague, W. E. Quality control of instruction: A logical analysis procedure. <u>Proceed-ings of the Human Factors Society 22nd Annual Meeting</u>. Detroit, October 1978, 91-97.

The author begins with a general discussion of the instructional systems development (ISD) process and indicates the important role of evaluation of this process. Although internal evaluation of whether training objectives are met and external evaluation of job performance are considered important, other types of evaluation are suggested to evaluate the early phases of instructional development. The instructional quality inventory (IQI) was developed to meet these needs. This inventory provides for a rational diagnosis of defects in instructional materials. The IQI is intended to evaluate materials along two dimensions: consistency among all materials and adequacy with respect to instructional technique. The primary aspect of the consistency dimension is to ensure scope, level, and content of test items are consistent with training objectives. Adequacy of instructional technique is determined by first placing instructional presentation into one of four display categories: telling/presenting a definition, telling/presenting an example, asking the definition of a concept, or asking about an example. The analyst assesses the adequacy of the display for the instruction in questions along four dimensions: (1) is the relevant information isolated or clearly identified, (2) is the student helped or prompted, (3) are examples matched to new situations to aid learning critical features, and (4) is there sufficient sampling from all difficulty levels. Three studies were conducted to determine the validity of the IQI in evaluating instructional materials. In these studies instructional materials were varied to affect either consistency of training objectives/test items or adequacy of instructional technique. Results confirmed that prescriptions from the IQI are actually obtained in student performance. A training manual for the use of the IQI was developed and evaluated in a training workshop for analysts. Results indicated that users could use the IQI reliably. A large-scale validation study is in progress.

Rigney, J. W., Cremer, R. H., Towne, D. M., Bond, N. A., Jr., & Mason, A. K. <u>Measurement and predictions of cognitive loadings in corrective maintenance tasks: I, A Bayesian approach</u> (Tech. Rep. No. 46). Los Angeles: University of Southern California, Department of Psychology, December 1965.

This report describes methods for analyzing the cognitive loadings involved in electronic troubleshooting tasks. A symptom-malfunction (S-M) matrix is introduced showing interrelationships between possible malfunctions and sets of symptoms. The Bayesian Electronic Trouble Shooting (BETS) model was developed as a criterion measure of troubleshooting ability. BETS can select at each step in the troubleshooting sequence the combination of test and test-point that has the greatest potential uncertainty reduction. Data were collected that demonstrated the effectiveness of the BETS model in troubleshooting. The BETS model has potential applications in teaching, as a design tool, and as a criterion measure of troubleshooting ability.

Salvendy, G., & Stewart, G. K. The prediction of operator performance on the basis of performance tests and biological measures. <u>Proceedings of the Human Factors Society 19th Annual Meeting</u>, Dallas, October 1975, 457-466.

This study investigated the hypothesis that the combination of biological measures and psychomotor performance test scores would provide a more valid personnel selection measure than just a psychomotor performance test score. Data were collected using the one-hole test elemental performance test and various biological measures. It was found that the most powerful predictors of job performance were the absolute values of the standard duration of basal interbeat intervals. The hypothesis that the combination of measures would be more effective than a single measure was supported.

Program Objective Memorandum (POM) were examined. Weaknesses in these procedures were identified, and a plan of action for their improvement was proposed. One major weakness identified by this report relates to the generation of resource requirement requests (RRRs). These RRRs, it was found, are based largely upon speculative information and are, at best, gross approximations of the requirements which will actually be faced for the fiscal year being planned (a 2- to 3-year planning horizon). However, rather than treating these as gross approximations and allowing flexibility within the system, the statement of RRRs does not change as expectations change. Another problem identified is that the Navy's training experts do not participate in the planning process at the macro, or final, decision making level (e.g., determining total manpower requirements). Similarly, decision makers in the Washington arena cannot view the training process at a micro level (i.e., the individual course level). A consequent void is created by this lack of communication betwen micro- and macro-level planners. One final problem with the training portion of the POM identified in this report is the absence of a model for use during final planning stages to examine training resource impacts upon various decisions. The authors propose the development of real-time interactive models to assess the effects of alternatives as they are considered.

In the appendices, Lindahl and May describe and identify weaknesses, and make recommendations pertaining to: (1) the generation of course requirements, (2) the generation of student input requirements, (3) the determination of instructor requirements, (4) the determination of support and facility requirements, and (5) training execution. Throughout these discussions, the need for increased quantification of the design process and commitment to systems analytic procedurs for instructional design and resource requirement planning is emphasized. Also, a reexamination of many assumptions which are used in planning is suggested.

Meister, D. A theoretical structure for personnel subsystem measurement. Proceedings of the 22nd Annual Human Factors Society Meeting, Detroit, October 1978, 474-478.

This paper (1) examines ways in which personnel subsystem measurement (PSM) differs from the controlled environment (CE) measurement characteristic of much human factors (HF) research, and (2) considers ways in which PSM, which is a measure of personnel performance in the actual work environment, is more useful than CE in HF research. Various types of PSM are differentiated. The author contends that the normative data obtained through PSM is more useful at this stage of HF development than experimental data, since what is needed for system development are masses of descriptive data that will enable HF psychologists to predict how systems will functions.

Miller, R. B., & Duffy, L. R. Design of training systems: The development of scaling procedures (Tech. Rep. TAEG-32). Orlando: Training Analysis and Evaluation Group, December 1976. (AD-A051 647)

Miller and Duffy explored the idea of applying subjective expected utility theory to the analysis of training system design and evaluation. Their basic premise was that the training system could be described by a series of attributes each having a certain utility. An increase in the value of some attributes would improve the systems utility, while an increase in other attributes would decrease the systems utility. Considerable development and justification of this concept was described including a statement of some potential attributes that could be used. These concepts could have significant impact upon assessment of a training program's overall desirability (i.e., utility) when compared to others.

4. Training Devices.

Brock, J. F. Maintenance training and simulation: Design processes and evaluation criteria. Proceedings of the Human Factors Society 22nd Annual Meeting, Detroit, October 1978, 260-266.

Four aspects of training unique to maintenance task training are identified to form the basis of discussion: (1) content, (2) importance of decision making, (3) importance of understanding system relationships, and (4) importance of knowing a wide variety of solution sequences. Three kinds of instructional requirements for maintenance training are identified: (1) procedural (preventive maintenance, systems checkout, and general inspection), (2) psychomotor (calibration, alignment, and repair), (3) schemata (fault detection and troubleshooting). Although the general instructional systems development (ISD) approach to training is the same for maintenance and operation jobs, certain specifics of ISD elements must be tailored for the job. Of these three kinds of requirements, the training of schemata is the most complex, least understood, and least suited to current ISD approaches. Recently, the armed forces have begun using simulators for maintenance training. Using the simulators in maintenance training has proven to be both effective and cost effective. Recent advances in computer technology have enhanced the role of simulators still more. Simulation provides the following advantages over use of actual equipment in maintenance training: cost, reliability, capability of being modified for hands-on practice, safety, and student performance as good or better.

The author lists seven simulation options: (1) actual equipment, (2) mockup, (3) 3-D/2-D mix of display, (4) 3-D schematic, (5) 2-D/image interface, (6) 2-D/keyboard interface, and (7) projected displays. The problem in designing maintenance training programs is not in finding techniques, but rather in determining what skills to be taught. There is confusion in the literature concerning the distinction between test reliability and validity, and instructional reliability and va· lity. The author proposes an adaptive model of instructional system evaluation in which measures of performance are taken at the completion of instruction and in the job environment. The first measure is an indicant of the internal state of the system, while the latter is an indicant of the impact of the system on consumer needs. Measures of the operating system can provide good measures of maintenance training performance: system downtimes, time to repair, supervisor ratings, and promotion comparisions of graduates and nongraduate of experimental programs. In computing cost savings which may be achieved by adoption of an innovative training approach, one should consider the overall impact on operation system performance which is realized by having better trained maintenance personnel.

Caro, P. W. Some current problems in simulator design, testing and use (HumRRO-PP-2-77). Alexandria: Human Resources Research Organization, March 1977.

This paper discusses some of the general and managerial problems that were observed in simulator projects in the Army, Navy, Air Force, and Coast Guard and that decrease the efficiency of simulator training. The problems identified are discussed within the appropriate life cycle phase of a simulator: the design phase, the testing phase, or the use phase.

Two problems are associated with the design phase. (1) Too often the simulator user is not involved in the design process. (2) Although their purpose is training, simulators are designed to reflect physical, rather than behavioral or training, models.

Two problems are associated with the simulator testing phase. (1) The testing conducted to determine the acceptability of a simulator is based on hardware considera-

tions and not on training usefulness. (2) The designer is given little feedback on the adequacy of the simulator for training.

Four problems are discussed in the simulator use phase. (1) Little attention has been given to the development of the technology of simulator training. (2) Simulator instructors are not trained adequately. (3) Simulator training is typically evaluated in terms of rate of device use, rather than in terms of training benefits or trainee performance. (4) No one knows whether simulator training programs are cost effective.

Harman, H. H. Designing and implementing the system model. In J. E. Uhlaner (Ed.), Psychological Research in National Defense Today (Tech. Rep. S-1). Washington, DC: U.S. Army Behavioral Science Research Laboratory, June 1967.

This paper covers the nature and advantages of simulation in training exercises, and presents several of the major training programs employing simulation techniques. It distinguishes between operations simulation and symbolic simulation. It lists the advantages of simulation techniques, including their flexibility and economy. The system training programs (STP) are used by the Air Force and Army to illustrate the process and usefulness of simulation in defense training systems.

Johnson, S. L. Training devices: Physical versus psychological simulation. Proceedings of the Human Factors Society 19th Annual Meeting, Dallas, October 1975, 24.

Three major categories of variables are involved in the behavioral aspects of simulation technology: (1) simulation fidelity, (2) external influences, and (3) measures of training device effectiveness. The concepts of simulation and training are discussed, and the distinction made between physical and psychological simulation. The implications of psychological simulation on the variables of simulation technology, as well as the job of determining simulation requirements for training devices, are discussed.

Karentz, V. Simulated maintenance training. The Second Symposium on Cost Effective Learning Through the Application of Computer Technology, Washington, DC, February 1973, 158-178.

The author describes how parameters are defined, transformed, and weighted for maintenance training simulators. Also, addressed is how the resultant training tasks configure a training computer exerciser.

Kelley, C. R., & Wargo, M. J. Adaptive techniques for synthetic flight training systems (Tech. Rep. NAVTRADEVCEN 68-C-0136-1). Orlando: Naval Training Device Center, October 1968.

This report is a discussion of the application of adaptive training techniques to synthetic flight training systems (SFTS), especially to the 2B24 training systems. It covers three basic requirements for any adaptive training system--performance measurement, adaptive variables, and the relation of adaptive variables to measured performance--and the major problem areas encountered in the design of adaptive training systems. An example is given to illustrate how adaptive training might be applied to the 2B24 SFTS, and a plan is presented for empirically establishing parameter settings, coefficients, and values for adaptive features of the 2B24 synthetic flight training system.

Klein, G. C., Kane, J. J., Chinn, A. A., & Jukes, A. O.   Analyzing training device effectiveness in cases where test data is inconclusive. Proceedings of the Human Factors Society 22nd Annual Meeting, Detroit, October 1978, 152-156.

The paper discusses BDM Corporation's experience in applying the TRAINVICE model of training device effectiveness prediction in conjunction with four CTEAs performed for the Army. Focus is upon the most recent analysis of the trainer for the ground/vehicular laser locator designator. In this particular analysis, the authors were forced to use the TRAINVICE model, as trainer test data were found to be unreliable. Two versions of the TRAINVICE model were applied (Wheaton, et al. 1976, & Narva, 1978) with approximately equal results. The value in the TRAINVICE analysis, according to the authors, was in providing additional support for conclusions based on the available test data, thereby strengthening these conclusions. Although the TRAINVICE model is seen to offer utility, such approaches must be considered initial efforts in the development of methods to predict training device effectiveness.

Semple, C. A., Caro, P. W., & Seay, D. E.   Simulator training requirements and effectiveness study (STRES). Proceedings of the Human Factors Society 22nd Annual Meeting, Detroit, October 1978, 251-255.

A long-term research study was conducted by the Air Force, with participation by the Army and Navy to obtain and organize data related to aircrew training devices (ATDs) so that ATDs can be specified, designed, and used in the most effective and efficient manner within aircrew training programs. Basic goals of the study include: (1) development of criteria to match training requirements to simulator features, (2) definition of principles for the effective and efficient use of ATDs, (3) development of principles for matching instructional features to specific training requirements, and (4) collection of data related to cost and worth-of-ownership of ATDs.

Shannon, R. H. Development of a training model for naval flight students. Proceedings of the Human Factors Society 18th Annual Meeting, Huntsville, AL, October 1974, 57-60.

This study was directed toward the development of a part-whole training model for naval flight students separating into component parts the maneuvers in presolo training. This involved: (1) developing highly detailed descriptions of all maneuvers in presolo training, (2) isolating those critical errors within each of the maneuvers, (3) performing two commonality analyses on the maneuvers (one based on similar flight tasks and the other on similar flight errors), and (4) developing inflight/simulation scenarios that could be used to impact upon both flight tasks and pilot errors. The results of this investigation seem to indicate the feasibility of the part-whole model outlined as being applicable not only to flight training, but also to student evaluation.

Smode, A. F., & Hall, E. R. Translating information requirements into training device fidelity requirements. Proceedings of the Human Factors Society 19th Annual Meeting, Dallas, October 1975, 33.

When training needs are not met by simulator capability, it is easy to assign responsibility to inadequacies in engineering, design, knowledge, and technique. However, inaccurate or inadequate information requirements may be equally responsible for device failure. The quality of device design is related directly to the amount and kind of information available for use in the design process. A solid base of human factors/training information is crucial. The human factors effort leads to statements of the specific training needs the device must be capable of meeting and the conditions for training that it must be able to create so they can be translated into design features. Fidelity of

simulation is constrained by economic, psychological, and technical factors. The four basic levels of fidelity useful in satisfying defined training requirements are discussed.

Winship, F. E. Technical publications and training and their impact on cost. *Proceedings of the 6th NTEC/Industry Conference*, Orlando, 1973.

The author, while not discounting the gains in training effectiveness brought about by training hardware, feels that significant cost savings may be realized through improvements in the technical publications construction process. The author feels that these savings will take place if random access pocket-size publications are made available, thus cutting down on unnecessary replacement of components and an even large savings in tracking down information.

5.   Job Performance Aids.

Ayoub, M. A., Cole, J. L., Sakala, M. K., & Smillie, R. J. *Final Report: Job performance aids: An assessment of needs; a literature review.* Washington, DC: Naval Air Systems Command, October 1974.

In regard to the maintenance and operation of attack systems, this report surveyed the little research conducted to date in the area of job performance aids. Recommendations were made for answering the following questions:

1.   What kinds of information does an operator need in the performance of a task?

2.   How can the operator generate a display which contains the required information?

3.   How should the display be structured so that the operator can extract the required information?

4.   How should an assignment be organized into tasks?

5.   What basic operations does the operator need to know in order to generate and to use the generated information?

6.   What are the costs and gains of varying various parameters in a job performance aid system?

Blanchard, R. E., & Laabs, G. J. *A personnel system concept with job performance aiding as a principal component: Preliminary model* (NPRDC Tech. Note 78-6). San Diego: Navy Personnel Research and Development Center, February 1978.

At present, the Navy is faced with rapidly increasing personnel and training costs accompanied by declining entry level skills. Huge amounts of money invested in early training are lost through attrition. One possible solution is to make training investments incrementally dependent upon the individuals shipboard performance, motivation, and interest. Job performance aiding (JPA) technology offers an approach that can make recruits effective contributors to shipboard operation and maintenance without substantial intial training. A job performance aid is a device or guide used on the job to provide the information necessary for satisfactory job performance. Since it frees the user from the necessity of actually learning the information, training time can be reduced. The purpose of this study was to conceptualize a functional personnel system using performance aiding. Primary objectives of model development were (1) to get individuals on the

job as quickly as possible with a minimum of initial training, (2) to provide for the advancement of qualified, career-oriented personnel, (3) to improve the utilization of lesser-aptitude personnel, (4) to encourage the development of a trained career force.

A general approach to personnel systems development was used. The model developed emphasized individuals with 4-year enlistment obligations. The model is in graphic form and includes functional steps and events, event length, and estimated time in service. The advantages and disadvantages of the model are discussed.

Booher, H. R. Job performance aiding systems technology selection algorithm. Proceedings of the Human Factors Society 22nd Annual Meeting, Detroit, October 1978, 158-162.

The article presents a nine-step decison aid for the selection of job performance aids (JPAs). This aid is seen to be appropriately used in early stages of training system development when trade-offs can be determined between JPAs, media, and training techniques. The decision aid was based on available data relating the kind of JPA to personnel characteristics, experience level of personnel, job equipment complexity, and task complexity. The type of JPA selected with this method is then related to an appropriate training technique. Experience in applying this decision aid indicates it is a workable approach. Work in progress will expand the method to include cost trade-offs among aiding, training, selection, and job design considerations.

Training Cost Estimation

Braby, R., Micheli, G. S., Morris, C. L., & Okraski, H. C. Staff study on cost and training effectiveness of proposed training systems (TAEG Rep. No. 1). Orlando: Training Analysis and Evaluation Group, June 1972.

One method of optimizing training media allocation on the basis of fixed training effectiveness and a minimum cost was developed at Naval Training Equipment Center (NTEC). This method employs a digital computer and linear programming techniques to provide the decision maker with the information needed to assess the costs and benefits of alternative training considerations. Specifically, based on the parameters of the training task and various training alternatives, the model identifies: (1) the least costly of several equally effective alternatives of achieving the training goals, (2) the alternative expected to produce the greatest training benefits or effectiveness for a given cost level, and (3) the relative costs of all alternatives and the advantages provided by each.

This model proceeds through a series of steps in which the necessary parameters are identified and systematically incorporated into various submodels. These, in turn, are used by the computer to generate the information needed by the decision maker in selecting the most appropriate media. Specifically, the task analysis and incoming skills and knowledge are combined to determine training tasks and stages of training. Media options and possible substitutions among them are then determined. Life-cycle cost factors are identified for each alternative media and analyzed with the previously determined data using linear programming techniques. Ultimately, this provides the decision maker with the information needed to select the most appropriate media.

Department of the Army. <u>Cost and operational effectiveness analysis in the materiel acquisition process.</u> (TRADOC Reg. No. 11-8). Fort Monroe, VA: Headquarters, United Army Training and Doctrine Command, March 1977.

This regulation outlines the purpose, scope, objectives, and essential elements involved in an assessment of the cost-effectiveness trade-offs of alternative systems proposed to reduce an Army force or mission deficiency for a given threat projection.

DiGialleonardo, F. R. <u>An approach for measuring benefit and cost in management and information systems</u> (NPRDC Tech. Rep. 75-21). San Diego: Navy Personnel Research and Development Center, October 1974. (AD-A014 209)

The author devised methods for subjectively measuring primarily the benefits and, to a lesser extent, the costs of elements and functions of nodes within a management and information system. This particular study is intended for inclusion in a larger analysis of the Navy's manpower planning system.

Doughty, P. L., Stern, H. W., & Thompson, C. <u>Guidelines for cost effectiveness analysis for Navy training and education</u> (NPRDC Spec. Rep. 76TQ-12). San Diego: Navy Personnel Research and Development Center, July 1976.

In this report a very thorough approach was presented which incorporated systems and cost analysis techniques into the analysis of the cost-effectiveness for Navy training and education. The authors proposed that alternatives should be considered not only on the basis of training products, but also on the basis of resources required to support each alternative. Additionally, as the training program is being developed and administered, constant consideration should be given to revising the assumptions used to select the particular alternative. As these assumptions change, or are invalidated, alternative training system strategies should be considered.

Three uses of cost-effectiveness analysis are identified: (1) descriptive analysis, which is intended to assess ongoing or completed programs; (2) comparative analysis, which involves the comparison of various alternative approaches; (3) predictive analysis, which involves the determination of costs and benefits of the proposed alternatives. Comparative analysis may involve both descriptive analyses (after-the-fact comparisons) and predictive analyses (a priori comparison of alternatives).

Two basic alternative approaches to cost-effectiveness analysis were presented: fixed effectiveness and fixed cost. The fixed-effectiveness approach implies that the level of training effectiveness is fixed (i.e., better training is unnecessary and less training is intolerable). In this case, the objective is to minimize overall cost. In the fixed-cost approach, the budget-level is fixed and the objective is to maximize the training system's effectiveness. In many cases, the actual approach taken permits cost/benefits trade-offs within limits; however, the concepts provide a valuable framework.

The six proposed cost analysis techniques listed in descending order of sophistication are: (1) cost benefit, (2) cost-effectiveness, (3) unit cost, (4) cardinal weighting, (5) ordinal ranking, and (6) best-guess decision making. Each of these techniques requires different data and analyses and, therefore, each is appropriate in different situations.

The authors also provide a taxonomy of training methods that describe the instructional process in sufficient detail to permit adequate cost analysis. The general categories are:

1. Passive presentation (e.g., verbal delivery, written delivery).
2. Student/instructor interactive presentations (e.g., discussion).
3. Point and graphic methods (e.g., programmed instruction, CAI).
4. Functional applications (e.g., laboratories, simulation).
5. Course management (e.g., computer-managed instruction).

In addition to these methods, the following variables are important in describing a training problem: student throughput, appropriateness of instructional methods, and student management.

Finally, the authors identified five cost categories and four cost driving activities. The cost categories are: (1) personnel, (2) hardware, (3) software, (4) facilities, and (5) overhead costs. Activities that might require resources from any of the cost categories and, therefore, drive these costs are: (1) research and development, (2) investment and production, (3) replacement, and (4) operation.

Hazer, K., Jr., & Ringler, D. Applicability of design-to-cost to simulator acquisition. Wright-Patterson Air Force Base, OH: Air Force Institute of Technology, June 1976. (AD-A030 231)

The authors assembled a set of criteria thought to be relevant to constructing a decision model for implementation of the design-to-cost (DTC) concept in simulator acquisition. Personnel familiar with the DTC concept then rated 25 of the 26 characteristics as viable decision elements for the applicability of the DTC concept toward weapon acquisition programs. Personnel from the Simulator Systems Program Office (Wright-Patterson AFB, OH) then judged the relevance of the 25 criteria as to their applicability toward simulator acquisition. Of the 25 characteristics, 15 were judged to be relevant, 6 marginally relevant depending on the size of the project, and 4 were thought to be irrelevant in simulator acquisition.

The authors concluded that DTC concepts not be implemented in simulator acquisition systems because (1) two of the characteristics judged not applicable ranked relatively high in the mean values rating and (2) a particular simulator considered had brief conceptual and definition phases, thus not supporting a use of the DTC concept. However, the use of DTC in simulator acquisition might be considered relevant if the simulator acquisition involves the development of a new simulation system or related component that is technologically feasible, but not available in private industry. Also, judged a viable instance of DTC application is when production techniques are used to produce a large number of simulation systems or components, and production costs are relatively large in comparison to other acquisition costs.

Johnson, S. L. Establishing training criteria on an economic basis, Proceedings of the Ninth NTEC/Industry Conference, Orlando: November 1976.

Johnson cast the problem of developing training programs on an economic basis within a quality control paradigm. He viewed training as a method of increasing the reliability of one component in a man-machine system. As with the quality control problem, the training analyst must attempt to minimize the risk of wasting resources (i.e., over-training the human), while also minimizing the risk of not providing enough training, and, thus, graduating unqualified personnel (producers' and consumers' risk, respectively). It is a problem of establishing an acceptable outgoing quality level of a training program on the basis of economics.

He identified the following parameters for use in his model:

P_{occ} = probability a situation will occur

P_o = probability a trainee will be able to perform the task without training

P_t = probability a trainee will be able to perform the task after training time t

$K_{\Delta t}$ = cost of t units of training

K_{occ} = cost of a failure to perform the task

Using these parameters, the probability the human will be able to perform the task after training time t is $(P_t - P_o)(P_{occ})$. The value or payoff for the training becomes $(P_t - P_o)$ $(P_{occ})(K_{occ})$. Similarly, the cost of training is $(K_{\Delta t})(t)$. Then, according to this model, the break-even point is when the value of the training equals its cost. That is when

$$\frac{(P_t - P_o)(P_{occ})(K_{occ})}{(K_{\Delta t})(t)} = 1$$

Hypothetical examples are used in this paper to illustrate the applicability of this model to the development of training. The point is well made that cost-effective training programs can be established using the same concepts that successfully ensure an adequate level of quality in an industrial production environment.

Jorgensen, C. C., & Hoffer, P. Prediction of training programs for use in cost training effectiveness analysis. El Paso: U.S. Army Research Institute for the Social and Behavioral Sciences, Fort Bliss Field Unit, January 1978.

Jorgensen and Hoffer developed a technique for selecting the most cost-effective media based on a comparison of training objective media requirements and candidate media characteristics. They state that estimation of media cost presents relatively minor problems when compared to the estimation of its training effectiveness. The primary goal of the report is to develop a technique for assessing the effectiveness of media alternatives for the training of specific tasks.

Their basic approach for determining media effectiveness involves the development of a set of matrices that describe: (1) the media requirements from the standpoint of most desirable instructional delivery for each task and (2) media characteristics from the standpoint of which characteristics are available in which media.

The columns of both matrices represent a set of variables describing the media in terms of capability and availability (e.g., color availability and characteristics of audio cues). The rows in the task matrix represent the various tasks to be trained. In this matrix, the values within each cell represent the desirability of the characteristic (identified by the column number) for training of task (identified by the row number). In the media characteristics matrix, the rows represent the various media alternatives (e.g., sound-slide, workbook, classroom, and simulator). In this matrix, the value within each cell represents the availability or unavailability of a particular characteristic for a particular media.

By comparison of the two matrices through matrix algebra, an analysis is made to determine which media has the most desirable combination of characteristics for the

training of each task. The selected media is designated as the optimal media from a training effectiveness standpoint. The relative desirability of alternate media can then be assessed by comparing the number of lacking and optimum characteristics. This difference, the authors proposed, should be a quantified measure of training effectiveness which could be used as the denominator in the cost-effectiveness ratio. Although the technique oversimplified the concept of media training effectiveness, it does take a significant step toward the quantification of the media selection process.

Martin, J. I., Koehler, E. A., & Mairs, L. S. Life cycle Navy enlisted billet costs--FY78, (NPRDC Spec. Rep. 78-14). San Diego: Navy Personnel Research and Development Center, July 1978.

The objective of this effort was to provide program managers and systems engineers with current data on life cycle costs of Navy enlisted personnel for 1-, 5-, 10-, 15-, and 20-year periods. These costs are provided by rating and pay grade. Availability of such data should enable managers to predict life cycle costs of operator and maintenance personnel. Therefore, candidate system approaches may be more easily compared in terms of their manpower requirements. Furthermore, comparisons may also consider hardware and software costs associated with each manpower concept.

Life cycle personnel costs include direct costs, training and retirement costs, and overhead costs associated with all personnel, regardless of rating and pay grade. It is presently anticipated that life cycle Navy enlisted billet costs will be recomputed, updated, and published at yearly intervals. Variables included in computation are billet cost, number of years in billet life, discount rate, and billet cost for first year.

Okraski, H. C., & Parrish, W. F., Jr. Acquisition cost estimating using simulation (TAEG Tech. Memo 75-4). Orlando: Training Analysis and Evaluation Group, September 1975. (AD-A015 624)

The acquisition-cost-estimating-using-simulation (ACES) model developed by the Training Analysis and Evaluation Group (TAEG), which is designed to determine the most probable costs of any hardware and/or software system, is especially useful when uncertainty exists in the design approach. In using ACES, the subsystems of a given system must be identified and then the possible technical approaches for realizing each subsystem are determined. Once this information is available, probability of occurrence for any approach can be assigned and cost estimates for each approach calculated. ACES works by randomly selecting subsystem costs according to the probability of occureence, and through repeated iterations (as many as 5000 or 6000) creating patterns of possible cost outcomes. Upon completion of simulation, a graph is plotted of probability versus least system cost, as well as a histogram of system cost distribution. These provide the program manager with a good feel for possible costs. The program is availabe to the public.

Skeen, J. R., & Jackson, A. E. A life cycle training cost model. San Diego: Navy Personnel Research and Development Center (in press).

This paper develops a general model to be used in determining the cost of training required throughout the life cycle of a Navy weapons system. System training takes place in a context of weapon system development model, which is described to indicate both the major categories of personnel who will require training and the timing of that training.

A training course was chosen as the focus of the model, because it is traditionally understood by both training managers and instructional technologists. The overall nature

and life cycle of a course are discussed, and the activities involved in initial course development are analyzed.

The end result of this analysis is a definition of a course in terms of a three-dimensional matrix whose axes are: (1) the four development phases (requirement specification phase, planning and design phase, development phase, and operation and control phase), (2) the six element costs (personnel, facilities, equipment, materials and supplies, transportation, and miscellaneous), and (3) the eight course activities (course content/media, student, instructor, hardware, facilities, evaluation, management, and support).

The training life cycle cost model thus developed is used to (1) estimate the number of different courses required, (2) estimate the number of repetitions and probable modifications, (3) estimate the costs of activities for each course development phase for each repetition, (4) sum across repetitions to obtain total estimated course cost, and (5) sum the costs of all individual courses to obtain the total estimated system training cost. The model is intended to be descriptive, rather than directive, and to provide a single coherent point of reference for use by system training manager, instructional technologists, and training cost accountants.

Swope, W. M. A primer on economic analysis for naval training systems (Tech. Rep. TAEG-30). Orlando: Training Analysis and Evaluation Group, March 1976.

A method for performing economic analysis is presented in a guidebook format for use by the Naval Education and Training Command. The primary function of this guidebook is to describe the components of economic analysis most relevant to training-system decison makers. Several points brought out in the report are of particular interest to persons involved in preliminary estimation of training system costs. During the identification of resource requirements, three resource classes were identified: (1) research and development costs, (2) implementation costs, and (3) operation and maintenance costs. Additionally, the following six subclasses of resources were identified: (1) instructional material development, (2) facilities, (3) equipment (4) expendable supplies, (5) personnel, and (6) student salaries. Presumably, if all of these classes and subclasses of resource requirements are adequately considered, an accurate estimate of total resource requirements will be obtained.

This report identifies several specific methods for obtaining resource requirement estimates. The first method involves the development of cost estimating relationships (CERs). These are the functional relationships between physical and performance attributes of a training system. Another method, termed the industrial engineering method, involves the breakdown of the training system into elements or components (e.g., skills) and estimating the costs of each component (e.g., resource requirements). These methods, will greatly assist in the development of any handbook for resource requirement estimation.

The report discusses the difficulties associated with estimating the effectiveness or benefits of training system alternatives. This aspect of training system analysis clearly presents significant difficulties with respect to cost/benefit analysis.

Other concepts relevant to the issue of long-term cost estimation of training systems are also presented. First, the adoption of advanced educational technology must always be considered by system designers. These advancements may provide the most efficient means of meeting the training objectives. Second, the possibilities of reorganizing small similar training groups into larger training groups should be considered in order to take

advantage of the economies associated with larger scale operations. Third, for the development of new weapons systems, the incorporation of existing large training programs should be considered.

Swope, W. M., & Cordell, C. C. Training resource classifications: Direct-indirect and fixed-variable cost categories (TAEG Tech. Memo 76-1). Orlando: Training Analysis and Evaluation Group, June 1976. (AD-A029 179)

Swope and Cordell investigate training resource costs to determine their relative sensitivity to lead times. Also, the authors developed a scheme for determining if particular cost is: (1) fixed or variable and (2) indirect or direct.

Swope, W. M., & Green. A guidebook for economic analysis in the Naval Education and Training Command (TAEG Rep. 55). Orlando: Training Analysis and Evaluation Group, April 1978.

This guidebook for performing economic analyses of training systems to aid decision makers of the Naval Education and Training Command is somewhat more procedurally oriented than Swope (1976), and offers a more algorithmic approach to the novice in economic analysis. It also considers the planning horizon and discount rate more extensively than the earlier article. Also, emphasis is more on where the resources originate (i.e., in-house or must be purchased and associated costs) than on how to determine resource requirements.

APPENDIX B

ADDITIONAL REFERENCES

System Concepts

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